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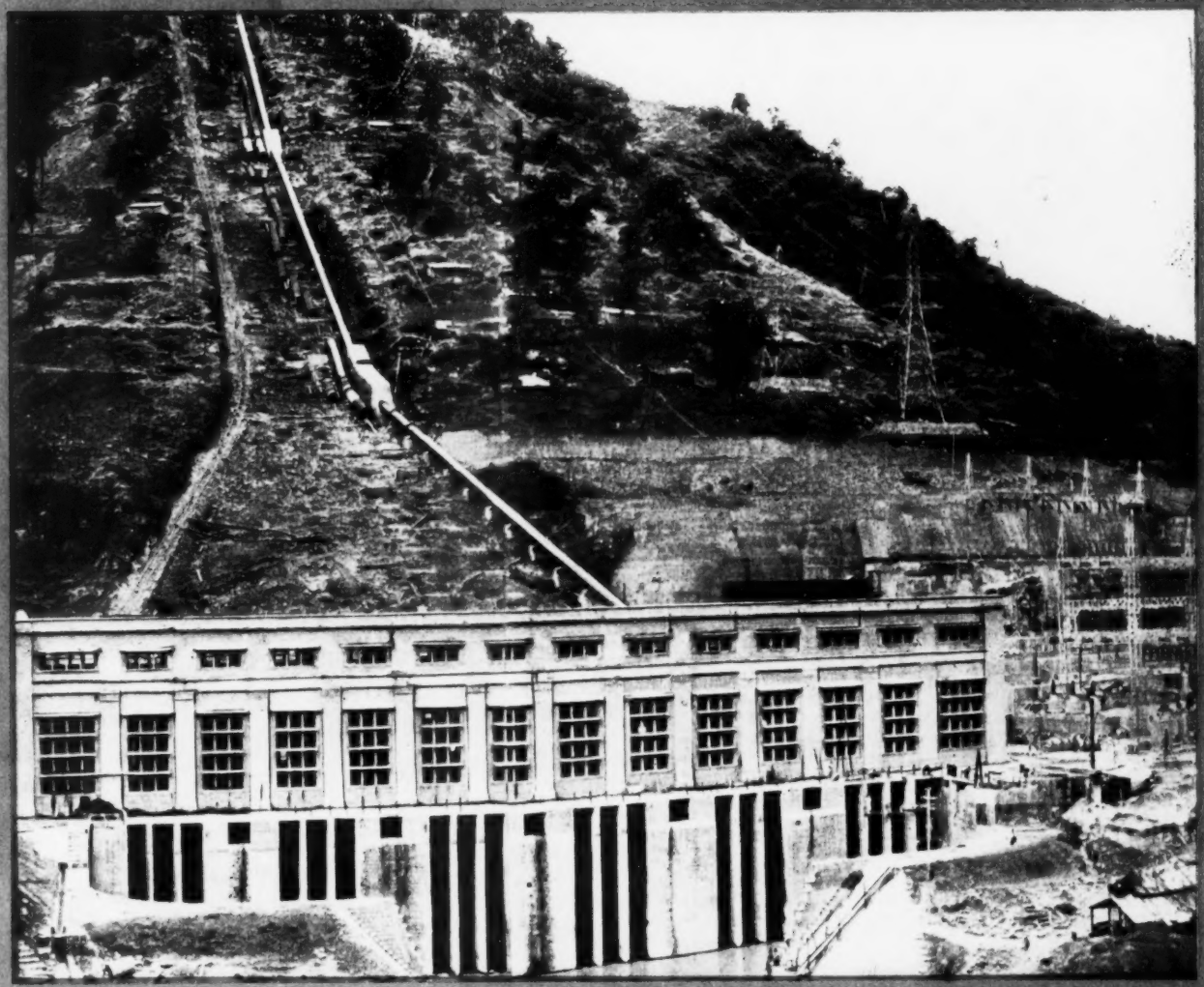

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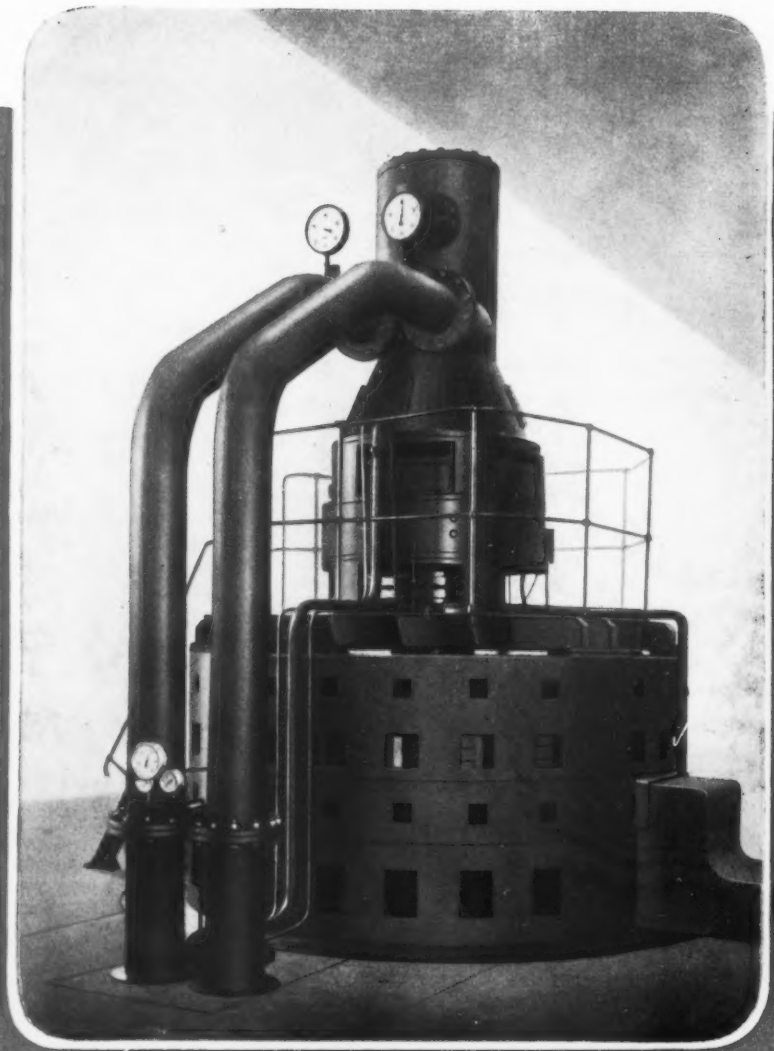

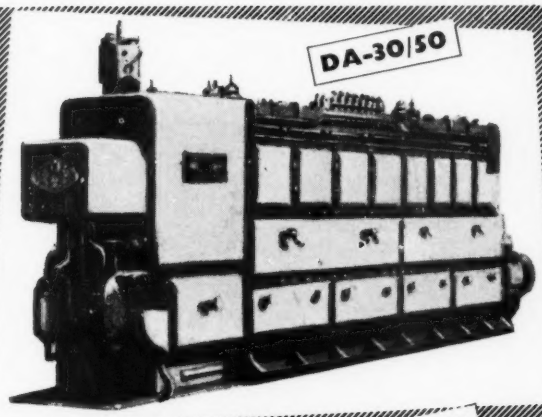

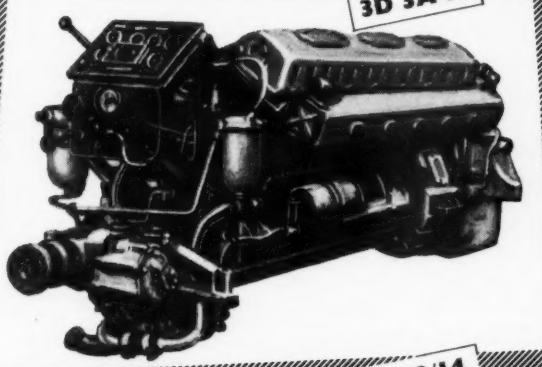

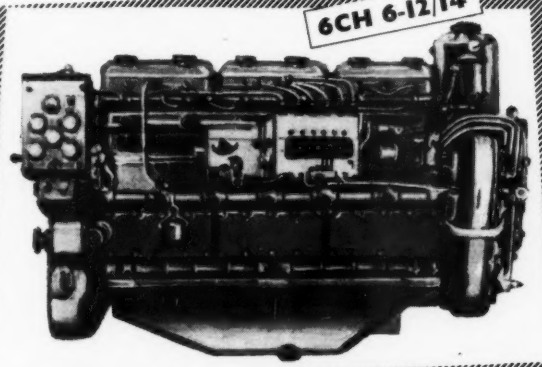

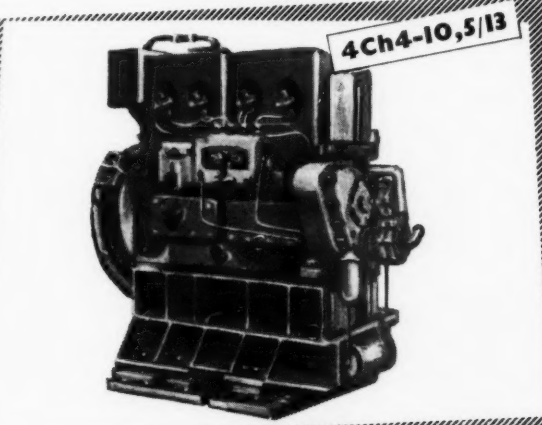

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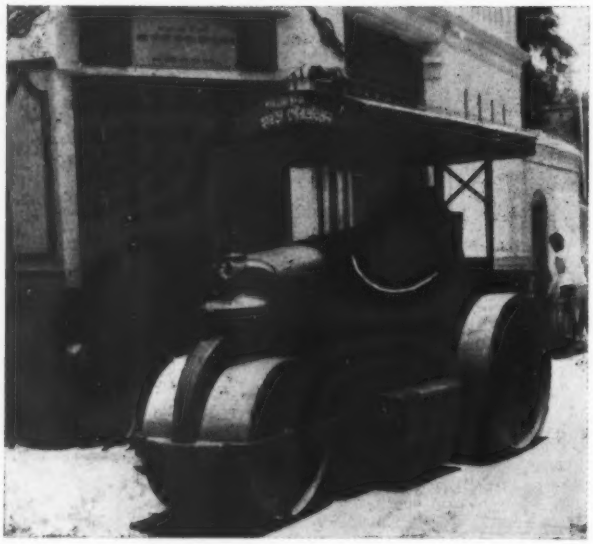

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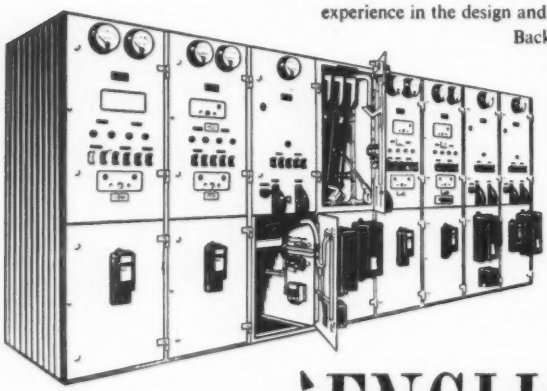

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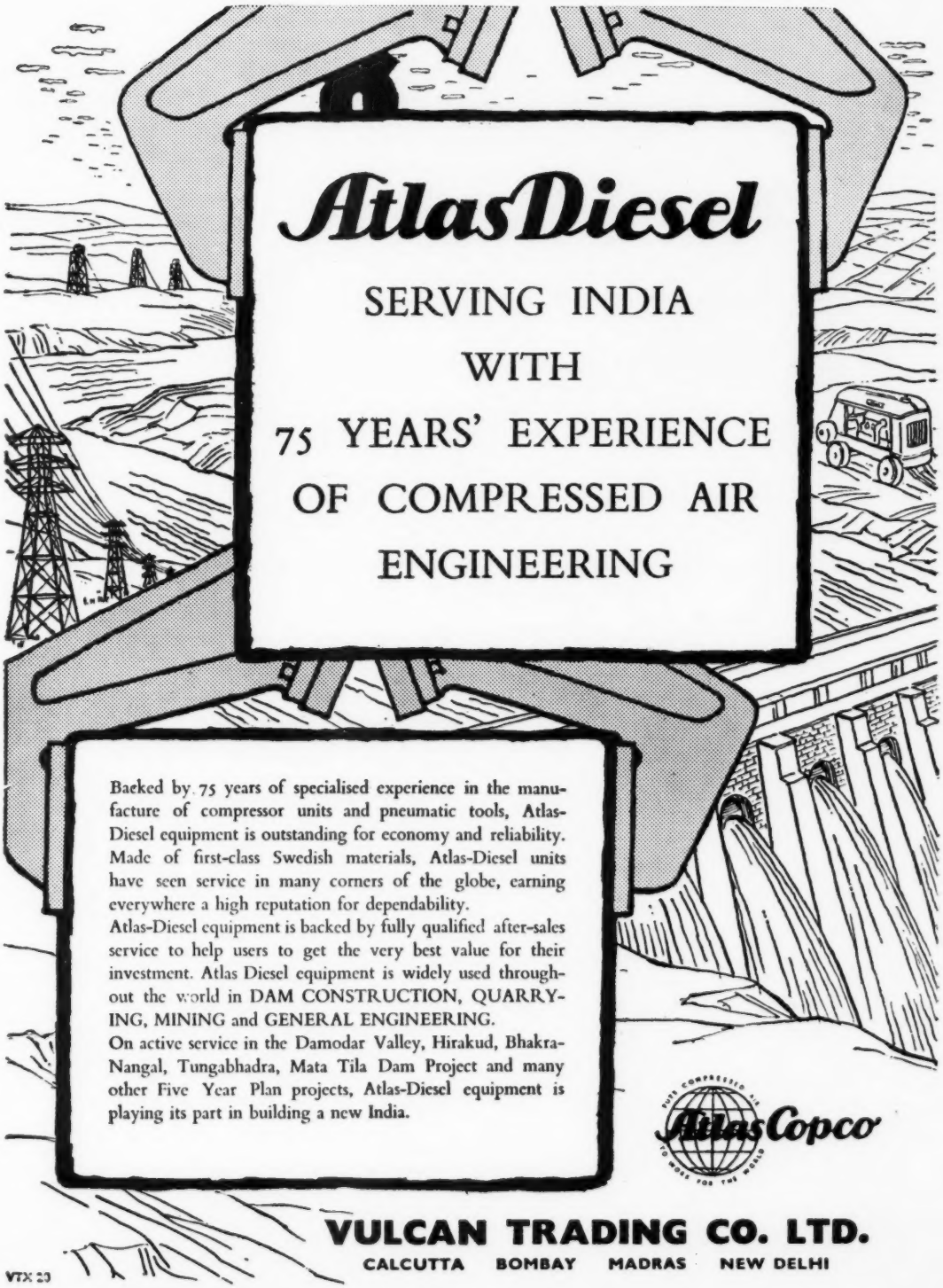
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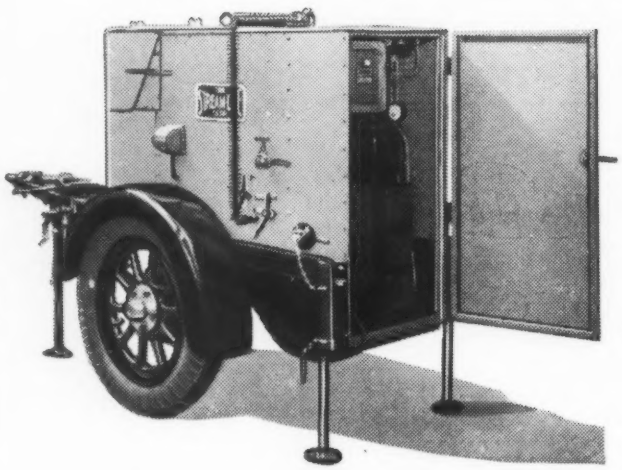

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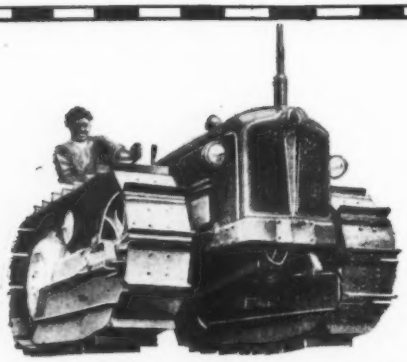

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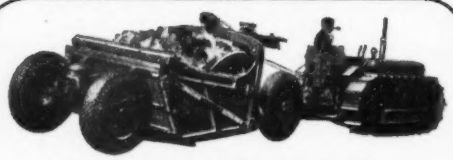

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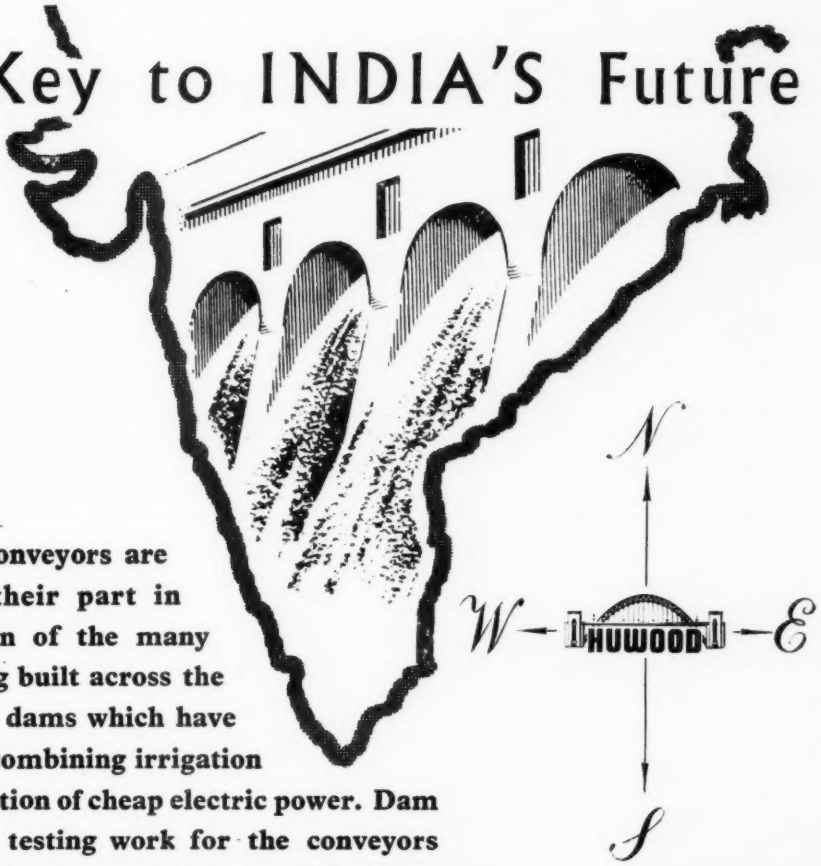

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1948: Goodyear supplied second longest over-land conveyor system at Bull Shoals Dam. Conveyor length approximately seven miles

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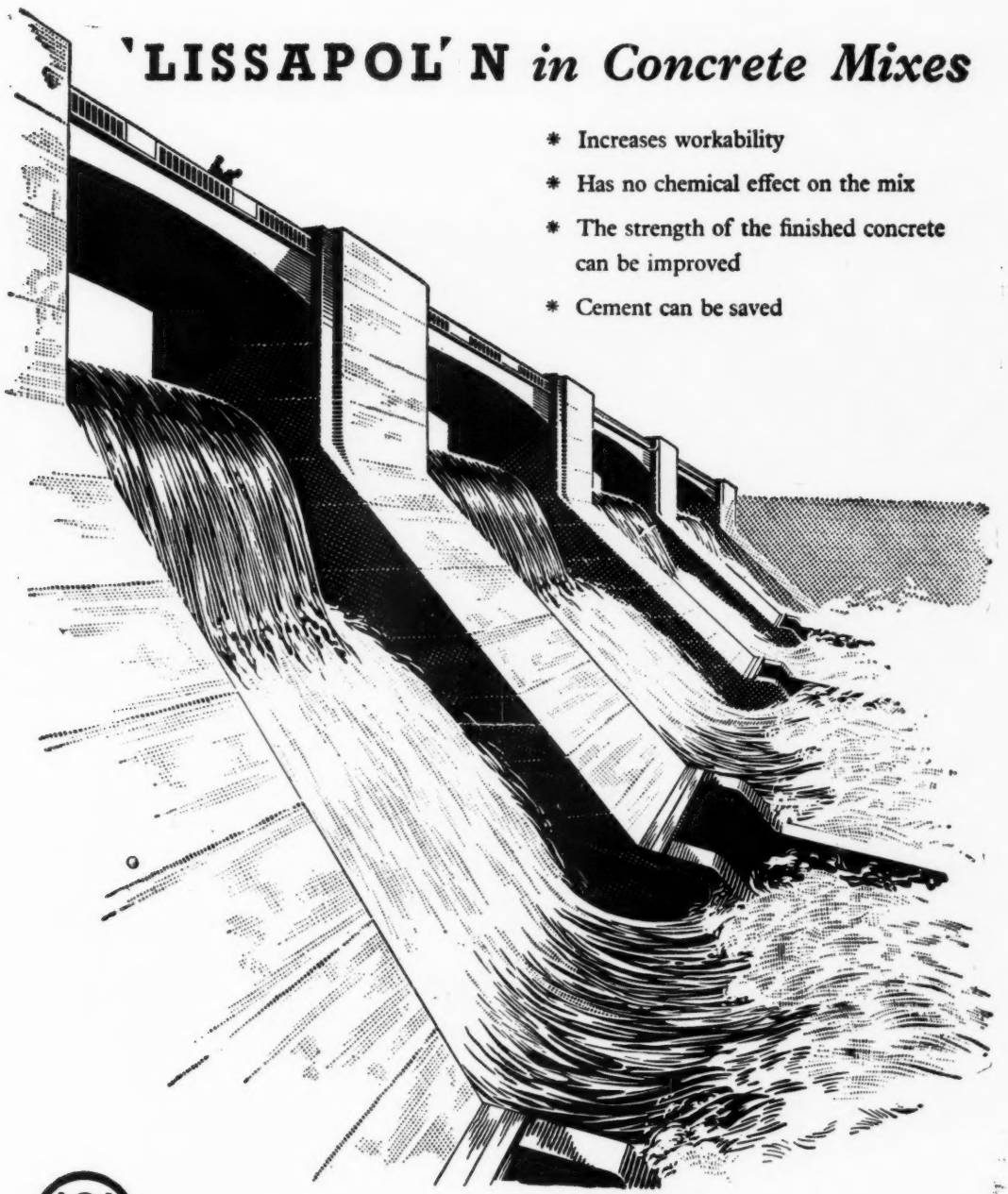

* Increases workability
* Has no chemical effect on the mix
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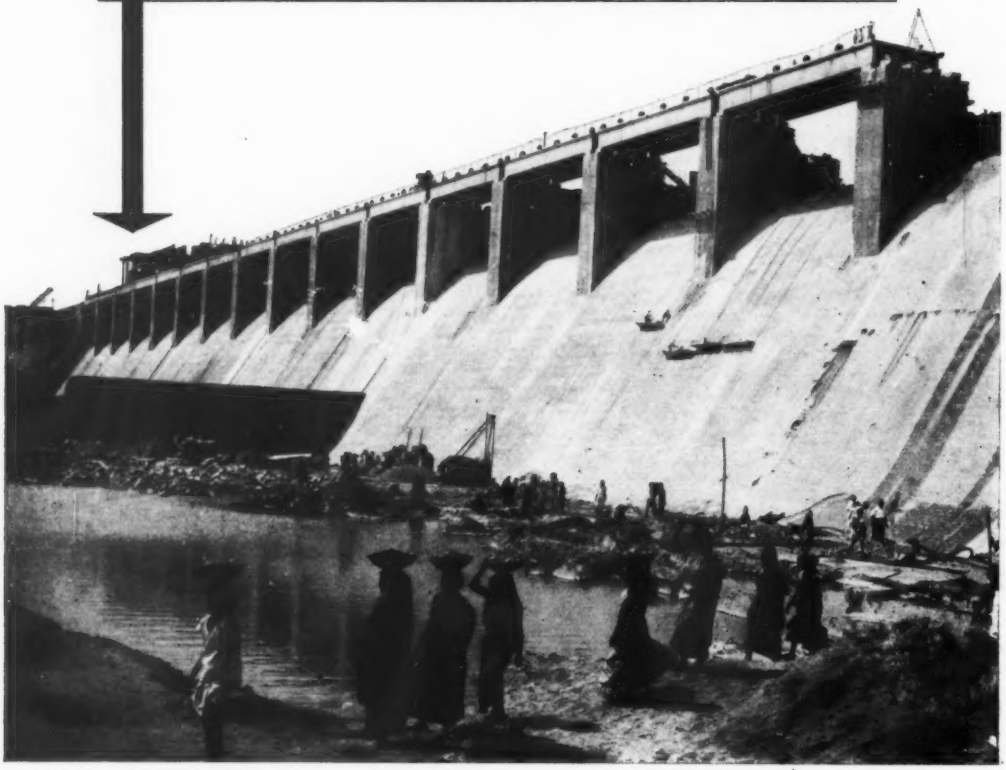

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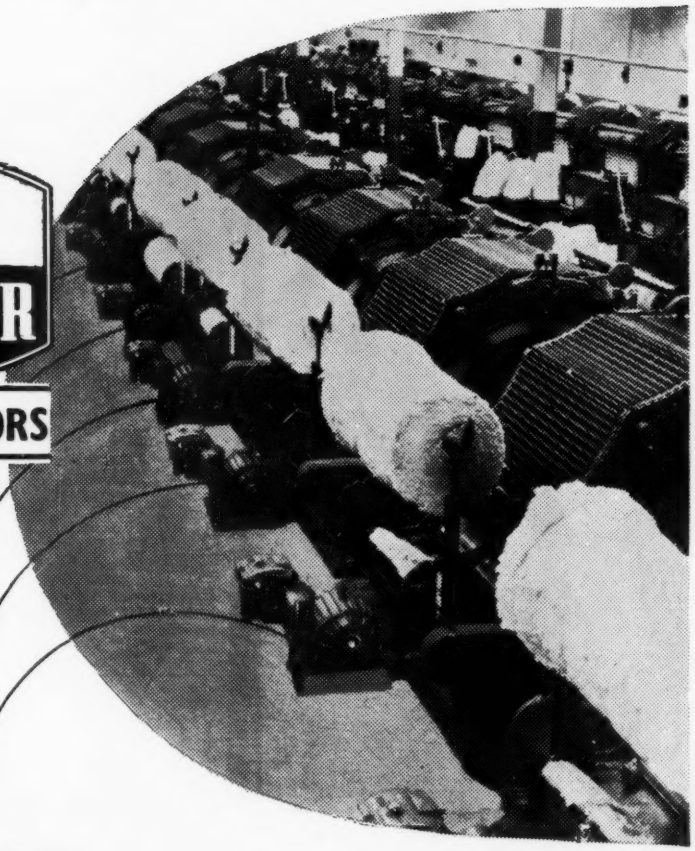

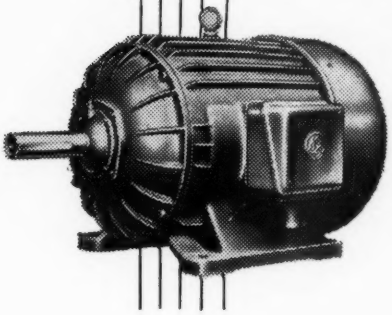

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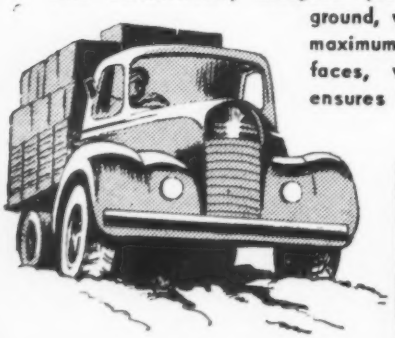

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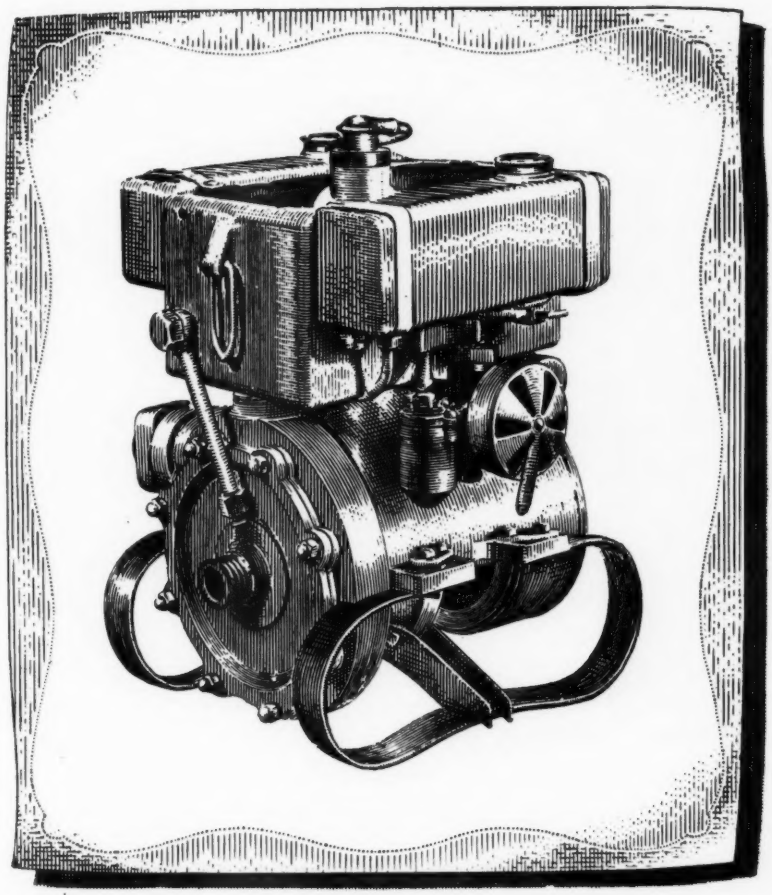

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : **K. K. Sinha** **P. K. Menon** : Mg. Editor

Vol. V **July, 1955** **No. 7**

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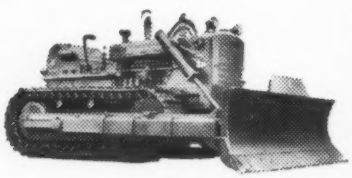
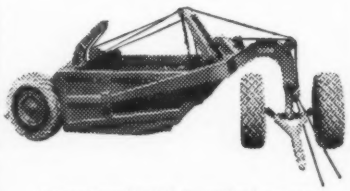
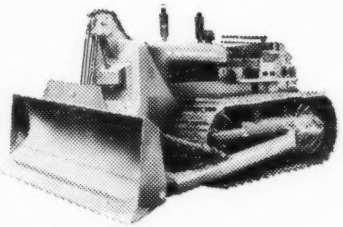


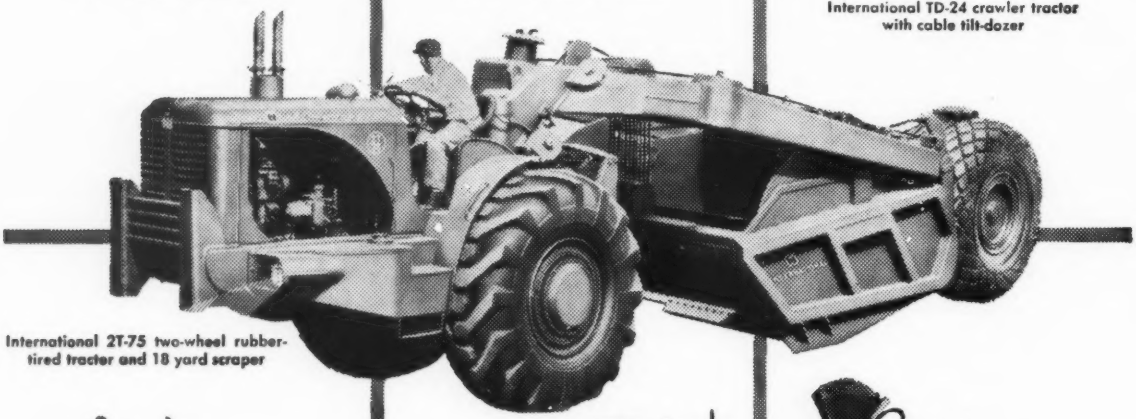
International TD-24 crawler tractor with hydraulic bullgrader



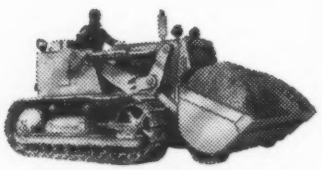
International B-250 four-wheel scraper for use with the TD-24 tractor



International TD-24 crawler tractor with cable tilt-dozer



International 2T-75 two-wheel rubber-tired tractor and 18 yard scraper



International TD-14A crawler tractor with hydraulic skid-shovel

International 2T-75 two-wheel rubber-tired tractor and bottom dump wagon

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INTERNATIONAL HARVESTER

Silting up of Reservoirs—I

N. S. JOSHI

Silting up of reservoirs is an extremely important problem facing the engineers of rivers valley projects in India. As more and more dams are being constructed, in accordance with the emphasis laid on river valley development in our National Plans, the issue is becoming increasingly crucial. But we have very little reliable data to go by in this matter. In the U.S.A. where a large number of reservoirs have been constructed, the question has grown into dangerous proportions. It is therefore very necessary that our enthusiasm for big dams be sobered by the experience in other countries as also by a study of our own rivers. Sri Joshi, who is already welknown for his painstaking and thoughtful criticism of some of our country's engineering policies, has provided a carefully analytical and constructive study of this grave problem of siltation. We draw special attention of all concerned to his paper.

AUTHOR

The article is meant to record suggestions regarding the estimation of the probable life of a reservoir to allow engineers and administrators to determine the advisaibility or otherwise of the execution of a project of which the reservoir forms an integral part.

[2] Fears of Silting up of Reservoirs

(2-1) One sometimes hears of criticism on the designs of certain reservoirs, to the effect that they (irrigation or power reservoirs under construction or consideration) would silt up in a few decades. One also hears of statements refuting the above and confirming the assumption of designers of reservoirs that the very minimum life of the reservoir in question would be 100 years, and probably that it would last for 400 years or more. Not only laymen but also engineers in other fields get puzzled at these statements and counter-statements. One has, under the circumstances, no alternative but to depend upon experts for opinion in the absence of a simple method to calculate the probable life of a given reservoir.

(2-2) The question of silting up of a reservoir is very vital ; upon its life will depend the success or failure of a scheme, whether meant for irrigation or for power. Though the responsibility about designs devolves mainly upon the designing engineer, it is very desirable—almost essential—that an independent examination of the problem should be possible by engineers not expert in that branch of engineering and also by administrators and laymen.

(2-3) Regarding obtaining opinion of experts, the practical difficulty lies in the fact that as soon as one asks for such an opinion the expert on the subject asks for data for silt-samples over a number of cross sections on the stream in question, collected at least once every day for a minimum of 10 years. Such data are generally not available, but even where such data have been collected, the quantity of bed-load still remains undetermined as no dependable method or technique to estimate that correctly is known. Experts say it is as low as 5% in some cases ; it is said to be as large as 20% or more in other cases.

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(2-4) In a country like India, aspiring to progress in stages by planning, this period of 10 years essential in collecting data of silt contents (even if the question of bed-load was kept out of sight) is equivalent to a denial of obtaining the advantage of planning and requiring postponement of such schemes by a period of 10 or 15 years. The country can not afford to lose this valuable period, particularly as other countries will be progressing in the meantime. Nor will it be correct to construct reservoirs indiscriminately and take serious risk. The problem boils down to finding out a safe course between postponing all such schemes by 10 or 15 years and taking the risk of constructing reservoirs that were very likely to silt up fast and thus going to have a short span of useful life.

[3] Data available in U.S.A. and in India

(3-1) Instances are quoted of reservoirs in U.S.A. which have outlived several centuries and also of reservoirs that have silted up within a few years (10 to 15) of their construction.

The rate of silting in Lake Meade (Colorado River) in the U.S.A. deserved to be mentioned first. The Colorado, it is estimated, brings down into the lake about 1,37,000 acre feet i.e., about 6,000 million cubic feet of silt, per year. The Lake was designed to hold 32 million acre feet of water and should, therefore, have a life of more than two hundred years (32 divided by 0.14) before complete silting up. Lake Meade is known to have made a successful scheme. It would not however be correct to conclude from the example of that lake in the U.S.A. that India in its present stage should also venture upon a similar scheme. Comments on this aspect will be found at the end of this paper.

(3-2) Appendices I, II & III give data about silting of reservoirs in the U.S.A. (See pages 6,7,8)

In Appendix I is given a statement of 43 Reservoirs in the U.S.A. with data about silting, surveys for which were carried out by the Soil Conservation Service, U.S.A. and data for which have been published at pages 120-121 of Technical Bulletin No. 524 on "Silting of Reservoirs". In Appendix II will be

found an extract from a statement printed on page 84 of "some principles of accelerated streams and valley sedimentation"—Technical Bulletin No. 695 U.S Department of Agriculture. This gives data for 21 Reservoirs in U.S.A. where erosion observed was in excess of 1 inch in 40 years. In Appendix III is reproduced a statement giving rates of annual loss of contents of reservoirs by silting of certain reservoirs in U.S.A. These are reproduced from page 20 of Miscellaneous Publication No. 521 of U.S. Department of Agriculture—"The Control of Reservoir Silting". This indicates probable life of 63 Reservoirs in the U.S.A.

In the foreward to this last named publication, the Chief of Soil Conservation Service writes as under.

"Water storage is a vital cog in the economy of War production in the United States. Our 9,000 larger Dams and impounding Reservoirs supply one-third of the Nation's electrical power, furnish water to areas where one-fifth of the Nation's people and about one half of its War industry are located... These dams and reservoirs have cost us nearly 5 billion dollars.

"Many of the reservoirs that are vitally important to our war efforts are losing 1, 2, 3 and even 5 per cent of their capacity every year because of silting that results mainly from soil erosion on agricultural and range lands. In some exceptional cases, important reservoirs have silted up in from 1 to 5 years. Already, nearly two thousand smaller reservoirs have been filled to the top of the dam with the debris of erosion—mostly washed out of unprotected fields and pastures. The annual cost of reservoir silting is upwards of 50 million dollars."

(3-3) Engineers and others in India would naturally be more interested to have data about the rate of silt deposition in reservoirs in India. Data available has been published in C.B.I. & P. publication No. 51 viz. "Silting of Reservoirs" by Raibahadur A. N. Khosla. Reservoirs have been constructed for irrigation schemes mainly in South India, in M.P. and in U.P. Khosla's book in question gives data for some reservoirs in Bombay, in U.P. and for a good many in M.P. No data have been published for Reservoirs in Mysore ; data for only two reservoirs have been given for reservoirs in the Hyderabad State. No data have been produced for the innumerable old tanks in Andhra, Mysore, Hyderabad and Madras. Names of about seven reservoirs in Bombay State give the total silt but the number of years during which the silt had accumulated is not given. The accuracy of the data included in the book is by no means the same in all cases ; in fact there is reason to believe that it varies widely. To draw definite conclusions from the data will be risky. The data from the C.B.I. publication in question has been tabulated and appears on page 9,10,30 of this paper in 4 statements as under :—

Statement V.H. i.e. "Very High" :—Gives data for 9 cases where deposition of silt per year per square mile of catchment exceeds, 1,00,000 c.ft.

Statement H. i.e. "High" :—Gives data for 15 cases where, deposition of silt per year per square mile of catchment exceeds 50,000 c.ft. but is less than 1,00,000 c.ft.

Statement L. i.e. "Low" :—Gives data for 25 cases where deposition of silt per year per square mile of catchment is between 10,000 and 50,000 c.ft.

Statement V.L. i.e. "Very Low" :—Gives data for 16 cases where deposition of silt per year per square mile of catchment is less than 10,000 c.ft.

[4] Mistakes inherent in data for silting

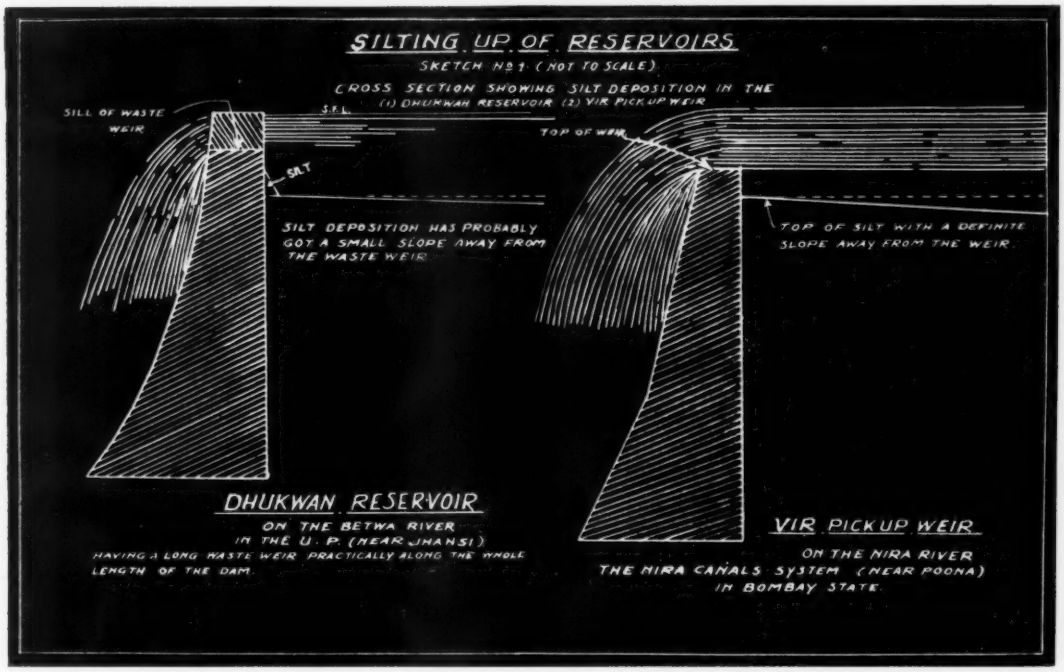
(4-1) Accepting all data in the C.B.I. Publication as equally dependable would be wrong ; this is particularly so as different methods are adopted at the time of different surveys for working out the figure of contents (and hence of silt deposited in reservoirs). The data thus derived leads sometimes to absurd results. This is best illustrated by the data for Dukwan Reservoir in U.P. The reservoir was constructed in the year 1907 and surveys for contents (and hence for silt) were carried out in 1916, 1930, 1932, 1937 and 1942. The rate of silting per year per square mile of catchment as worked out from the data obtained from these surveys gives results as under.

Period		No. of years	Silt deposited per square mile of catchment per year (C.Ft.)
From	To		
1907	1916	9	7,600
1916	1930	14	5,500
1930	1932	2	6,600
1932	1937	5	—5,300 . . . Scour
1937	1942	5	Negligible
Average :			
1907	1942	35	3,700

The danger involved in accepting the average figures or the figure for any particular period needs no comments.

There is also another reason. No reservoir provided with a waste-weir can ever silt up by 100%. Floods passing over the weir create a scooping action and do not allow the silt to deposit in a few feet below the sill of the waste-weir. Sketch No. 1 illustrates this. (p.3) This phenomena is seen prominently in the case of all (pick-up) weirs and of reservoirs which have silted up to within a few feet of the sill of the waste weir. That alone can explain the fact that many petty tanks in Madras, Andhra, Mysore and Hyderabad States continue to have a fair capacity even after several hundred years after construction.

(4-2) Unfortunately, the year when the reservo silted up nearly completely i.e., the year from which scooping action began is difficult to determine and is in


SILTING UP OF RESERVOIRS
SKETCH No. 1 (NOT TO SCALE)
CROSS SECTION SHOWING SILT DEPOSITION IN THE (1) DHUKWAN RESERVOIR (2) VIR PICK UP WEIR
SILL OF WASTE WEIR
S.F.L.
TOP OF WEIR
SILT
SILT DEPOSITION HAS PROBABLY GOT A SMALL SLOPE AWAY FROM THE WASTE WEIR
TOP OF SILT WITH A DEFINITE SLOPE AWAY FROM THE WEIR.
DHUKWAN RESERVOIR
ON THE BETWA RIVER IN THE U.P. (NEAR JHANSI) HAVING A LONG WASTE WEIR PRACTICALLY ALONG THE WHOLE LENGTH OF THE DAM.
VIR PICKUP WEIR
ON THE NIRA RIVER THE NIRA CANALS SYSTEM (NEAR POONA) IN BOMBAY STATE.

any case not recorded : in fact the existence of this scooping action does not appear to have received the attention of observers.

This action along with mistaken figures inherent in the data for silt deposition based on different methods of surveys, is almost certain to result in incorrect figures and to lead to incorrect conclusions being drawn from the figures available.

Owing to these difficulties inherent in the data on silting of reservoirs, mere collection of data for more reservoirs will not help formulation of rules for correlating silt per square mile per year on rational factors like the steepness of slope. Reasons which make formulation of dependable rules on this problem impossible have been explained in paragraph 8.

(4-3) "Statement No. A from a paper read by the author viz. "Silt Deposition in Tank Basins in Trap rock zones of Bombay State with 20 to 30 inches of annual rain-fall" read at and published by the World Conference on Large Dams (New Delhi 1951), is reproduced as Table No. 1. C.B.I. Publication No. 51 includes some of the tanks in the list; certain (small) differences are found in the two publications in the data for the same tank. The author had the advantage of visiting the tanks in question personally and obtaining data on spot after scrutiny of the figures.

[5] The real cause of anxiety and difficulty experienced

(5-1) It will be seen that the life of many reservoirs listed in Appendices I and III for certain reservoirs in U.S.A. is smaller than even 50 years. In this connection, it is necessary to record that the books from which these data have been reproduced were published with a view to explaining the importance of soil conservation by measures like contour bunding to stop denudation. It is not unlikely that there was therefore some bias and a tendency to exaggerate the rate of silting. The propagandists of soil conservation in India state that agricultural land was being denuded in certain areas in the Eastern (famine-stricken) part of Bombay State at a rate of about 1 inch per year and that about 1/3 to 1/5th inch per year was a fair average figure applicable to large areas there. These figures of rates of denudation have been quoted in publications of workers in soil conservation and of advocates of dry farming. Had the average rate of denudation been 1/3" or 1/5" per year, the silt brought down annually by streams and deposited in the reservoirs in the said Eastern part of Bombay Deccan would have been of the order of 7,75,000 and 4,60,000 c.ft. respectively per year per square mile of catchment. Tanks in the said region are, generally speaking, designed for a run-off of about 5 to 10 M.C.ft. per square mile of catchment. Had the rate of denudation been equal to 1/3rd or 1/5th inch per year, (corresponding to silt deposition of 0.78 and 0.46 M.C.ft. per year), the reservoirs would have completely silted up in a period of only about 6 to 20 years.

The fact that most reservoirs in that area have out-lived a period of over 60 years and have not lost even 50% of their contents by silting, is sufficient to prove that the rate of denudation is much smaller i.e. only a small fraction of what is quoted by the advocates of soil conservation. Even admitting that some prejudice in support of a proposal (contour bunding in this case) was inevitable and inherent in

the data published by propagandists, the exaggeration in quoting the rate of denudation as 1/5th inch per year when it is really of the order of 1/50th inch is unjustifiable.

(5-2) On the other hand, Irrigation Engineers proposing large reservoirs for irrigation appear to hold an opinion that there need be no anxiety about reservoirs silting up quickly. They are probably misled by the cases of certain reservoirs which have a long life. The life of the New Lake Whiting (Bhatghar) and of the Lake Arthur Hill (Bhandardara) in Bombay will be of the order of 2,000 years ; that of Ramtek in M.P. will exceed 500 years. A few other reservoirs with a life of more than 500 years can be quoted. But to suppose that other reservoirs will have comparably long life will be wrong. Statements "V.H." and "H" will illustrate.

What is really required is the truth, free from bias of either type. As stated already the most modern method of measuring the average quantity of silt conveyed by a stream per year will require very elaborate and costly arrangements. Besides, the collection of these figures will require a period of over 10 years : and even so the estimates of bed-load of silt will be a matter for speculation. In practice, it is impossible to keep waiting for such long periods before drawing out a project. It is essential therefore to devise some fairly simple and dependable (though approximate) method, which will give a general idea of the risk involved owing to silting of a proposed reservoir.

[6] Misconceptions regarding utility of scouring slucies and about other measures as desilting devices

(6-1) Many engineers suffer under the impressionthat provision of scouring sluices is a successful remedy to remove the silt that might otherwise deposit or has already deposited in a reservoir. Owing to this prejudicial tendency, it is not uncommon to find engineers wrongly quoting examples of certain non-silting reservoirs.

The Aswan Lake on the Nile is quoted as a typical example and the Lake Whiting in Bombay State is quoted as another. The latter is discussed first.

Amongst important cases of reservoirs with long life, Miscellaneous Publication No. 521 U.S. Department of Agriculture—"The Control of Reservoir Silting", quotes the example of the Lake Whiting in Bombay (India), as one where silt deposition was largely reduced and kept very low by the provision of scouring sluices. It can be shown easily, however, that the conclusion drawn is incorrect. It is true that the old Bhatghar Dam, constructed in the eighties of the last century, was provided with 15 undersluices, in the river-bed portion. The fact that the Lake is nearly free from silt has, however, nothing to do with the said under-sluices. This can be proved by comparing cases of other reservoirs provided with undersluices. The Chankapur Dam in the (same) Bombay State e.g. is provided with scouring-sluices of a size and shape and installed in a position (the river-bed portion) comparable to that in the old Bhatghar Dam but the Chankapur Lake is silting up inspite of these. While the example of Lake Whiting has attracted the notice of Officers of the U.S. Department of Agriculture, they do not appear to have noticed the sad tale of the lake formed by the Chankapur Dam. The said publication also refers to the provision of river-bed sluices in the new Lloyd Dam at Bhatghar. It must be stated that absence of silt in the Lake Whiting was not achieved by the Undersluices in the old Dam nor by the river-bed sluices in the new Dam at Bhatghar. The river-bed sluices in the new Dam are not, by standing orders, even permitted to be opened during periods of floods and hence they are as good as non-existing, so far as the problem of scouring out of silt is concerned. They are opened during the hot weather, i.e. after the level of the water is so low that it (the water) can not be let down by other and higher outlet gates. By that time all silt has settled down. In short the so called river-bed sluices do not serve as scouring sluices but only as outlet gates.

(6-2) The real cause of the Lake Whiting being free from silt is the small catchment area and the high intensity of rainfall on that. The catchment area is only 128 square miles while the average rainfall is about 140 inches. Judging by the figure quoted in C.B.I.P. Publiction of Lake Fife, 100,000 c.ft. would be a liberal estimate of the amount of silt brought down from the said catchment per square mile per year and the 128 square miles of the catchment probably bring down only about 13 M.C. ft. of silt annually. Contents of the new Lake Whiting are 24,000 M.C. ft. Even if there were no undersluices, the lake will have a life of (24,000 divided by 13) nearly 2,000 years. To attribute the absence of silt deposition to the provision of undersluices is thus obviously most misleading. Even if the quantity of silt brought down annually was assumed to be 2,00,000 C.ft., the Life of new Lake Whiting will be 1,000 years and the effect of silting will go unnoticed for several centuries.

(6-3) A comparison between the old and the new Lake Whiting at Bhatghar and the lake formed by the Chankapur Dam will prove useful. Scouring (or river-bed) sluices were provided in all cases. The following statement gives relevant details of all the three dams viz. Chankapur Dam, the old and the new Dams at Bhatghar and the lakes formed by them. As stated already, though scouring-sluices were provided in all the 3 cases, none of them were worked (during floods at least) during the past 25 years.

Statement comparing 3 Lakes in the Bombay State

1.	Name of the Dam	Chankapur	Old Bhatghar	New Bhatghar (or Lloyd)
2.	Name of the Lake	Chankapur	Whiting	Whiting
3.	Year of completion of Dam (in round figures)	1910	1890	1925
4.	Catchment area in Sq. Miles	107	128	128
5.	Average rainfall in catchment Inches	51	140	140
6.	Designed contents in M.C. ft	1500	5300	24000
7.	Average run-off from catchment in M.C. ft.	5000	34000	34000
7A.	Average run-off from catchment in inches	20	114	114
8.	Minimum run-off M.C. ft per year (in round figures)	1350	15000	15000
9.	Number of undersluices	7	15	8
10.	Width of ,, ,, Ft.	4	4	4′) Dia
11.	Height of ,, ,, Ft.	10	8	4′) pipe
12.	Remarks about Silt deposit.	Over 40′ in river-bed filled up with silt. The lower irrigation sluice already affected.	Little Silt	Little Silt

If undersluices were useful for desilting, the Chankapur Tank would also have been free from silt on lines similar to those of Lake Whiting. Actually the long life of Lake Whiting has nothing to do with the provision of river-bed sluices.

(6-4) A popular belief is found to exist in certain quarters that silt deposited in reservoirs should and could be removed mechanically. The impracticability of such a proposition can be easily proved by a few figures.

The rate of excavation of silt plus lead can not be lower than Rs. 4 per 100 c.ft. This is equivalent to Rs. 40,000 per M.C. ft. This may be compared to the cost of storage per M.C. ft. of reservoirs which ranges between Rs. 2000 and Rs. 5000. The cost of a M.C. ft. of *additional* storage by raising an existing dam is smaller still.

Obviously, physical removal of silt and throwing it out of the reservoir is an uneconomic proposition in the case of most (if not of all) irrigation and power schemes. Stirring of reservoir bed so as to off the silt with surplussing floods etc. or through outlet gates or pumping it out is probably as costly or even more costly, and in any case nothing like so cheap as constructing a new storage or like raising the height of an existing dam. In short, desilting is an impracticable proposition in the case of Irrigation and Power reservoirs.

(6-5) Whether tiers of under-sluices on the lines of the Aswan will be successful in keeping reservoirs free from silt, is a matter of speculation at this stage. Not many examples of the type of Aswan could be quoted. The Aswan Dam forms, for all practical purposes, a "Barrage." The secret of success of sluices in not allowing silt in large quantities to deposit lies in the creation of silt-conveying and other hydraulic conditions comparable to those of the normal river upstream. Obviously, this is possible with certain depths, but not for all. That appears to fit in with the opinion expressed that "If for hydro-electric development or for irrigation expansion, a steady head has to be maintained at the reservoir, the silting will be more pronounced and progressive."

It is feared by many that large quantities of silt will get deposited in the Aswan lake than before as soon as hydro-electric and irrigation developments require the date of beginning of filling of the Aswan Lake being set back to avail of increase in capacity.

(6-6) There is also another important factor viz. the tackle for operating the gates. The example of Chankapur is important from that point of view. The under-sluice gates of Chankapur have a story to tell ; the gates were designed to be raised by ropes and winches and were expected to be lowered down into their seats by their own weight.

Owing to rusting, which was probably accentuated due to contact with silt, the gates of undersluices at Chankapur could not be raised easily and when efforts were made to raise them by strong hydraulic jacks (the winches and ropes having failed), the raised gate could not be closed. The 'moral' to be drawn from the sad experience is that one must not depend upon gates to close down in such cases by their own weight and that a positive type of arrangment for closing was essential, even presuming that such tiers of undersluices could be used as a device for desilting or for reducing silt deposition.

It is also worth recording that the suspended silt load of the Nile above Aswan per unit area of catchment is only about 10 or 15% of that of the Sutlej or Mahanadi. There is therefore not much of a comparison between the cases like the proposed reservoirs at Hirakud in India and that of the Nile in Egypt to create a faith in the success of the tiers of sluices in river-bed.

(6-7) Some recommend contour bunding as a measure to minimize silting.

As contour bunding is effective on moderately sloping agricultural lands to trap silt, it is possible that the same remedy may help minimising silting of reservoirs only in such catchments and that too for a few years only. The efficiency of contour bunds in steep and in very steep catchments is however doubtful. In any case, as contour bunding in steep areas will not be useful by way of improvements to agricultural fields, such a proposal requires the whole cost to be borne by the storage reservoir itself. The question of cost will need very careful consideration. A few calculations show that cost of contour bunding per M.C. Ft of storage in the four categories, A,B,C & D referred to in the Table in para (9-5) will be 427, 640, 3200 and 12800 rupees per M.C. Ft. of designed storage. As cost of storage per M.C.Ft. varied between 2000 and 5000 Rs. per M.C. Ft. It is obvious that contour bunding is far too costly in the case of categories C & D and hence impracticable, unless the cost charged to storage is a very small fraction. The cost is not quite so prohibitive in categories A & B; but probably the remedy is not needed there, as these types have a long life. However, the fact that along with reduction in silt, contour bunding is very likely to also reduce the run off, needs very careful attention. The remedy must not be worse than the disease itself. It is feared the contour bunds in the catchment area may, in fact, cause more harm than good, except probably in the few cases where the designed storage capacity is a small fraction of the natural run off from the catchment.

(*To be continued*)

APPENDIX—I

Reservoirs surveyed by the Soil Conservation Services, U.S.A. 1934-38

Region, use and name of reservoir	*Location*	*Area of watershed Sq. Miles*	*Annual Depletion of storage Per cent*	*Life in years (rounded figure)*
1	2	3	4	5
SOUTHERN STATES				
Water Supply				
Barcroft Reservoir	Alexendria Va	14.5	0.20	500
Bay View Reservoir	Birmingham Ala	72.3	.81	120
Burlington Reservoir	Burlington N.C.	105.2	1.10	90
Burnt Mills Reservoir	Silver Spring, Md.	27.0	5.96	20
Franklinton Reservoir	Franklinton N.C.	1.13	1.60	60
Green-bore Reservoir	Grenbore, N.C.	74.1	.79	120
High Point Reservoir	High Point N.C.	62.8	.87	110
High Point Res. (1938 Survey)	-do-	62.8	.71	140
Lake Concord	Kannapolis N.C.	4.7	.65	160
Lake Harris	Tascaloosa Ala	30.0	.29	350
Lake Lee	Monroe N.C.	50.5	1.85	60
Lake Purdy	Birmingham Ala	41.74	0.10	1000
Lancaster Reservoir	Lancaster S.C.	9.4	1.60	60
Lake Michie	Durham N.C.	167.5	.36	280
Spartanburg Reservoir	Spartnaburg S.C.	91.0	2.09	50
University Lake	Chapel Hill, N.C.	30.6	1.14	90
Power Development				
High Rock Reservoir	Salisbury N.C.	3,930	.62	160
Lay Reservoir	Sylacauga Ala	9,087	.52	190
Lloyd Shoals Reservoir	Jackson, Gha	1,414	.51	195
New River Reservoir	.....	1,320	1.84	60
Buck Reservoir	Ivanhoe, Va		.98	100
Byllesby Reservoir	Byllesby, Va		2.54	40
Fields Reservoir	Mouth of Wilson, Va		7.15	20
Washington Mills Reservoir	Fries, Va		2.47	40

1	2	3	4	5
Recreation				
Greenbelt Lake	Greenbelt	.83	3.19	30
SOUTH CENTRAL STATES				
Water Supply				
Bloomer Lake	Stillwater, Okla	9.12	.59	170
Clinton Reservoir	Clinton, Okla	23.0	1.33	80
Grand Saline Reservoir	Grand Saline, Tex.	2.12	.31	30
Guthrie Reservoir	Guthrie, Okla	13.3	1.03	100
Lake Boonvelle	Boonville, Ark	2.6	.40	250
Lake Crook	Paris, Tex.	51.6	.49	200
Lake Gibbons	-do-	1.26	.15	660
Lake Sapulpa	Sapulpa, Okla	8.72	.74	130
Lake Spavnaw	Spanvinaw, Okla	400	.34	300
Lake Waco (1935 Survey)	Waco, Tex.	1,662	2.88	30
Lake Waco (1936 Survey)	-do-	1,662	3.34	30
Rogers Municipal Reservoir	Roger, Tex.	.55	1.91	50
White Rock Lake	Dallas, Tex.	99.1	.86	120
Wills Point Reservoir	Wills Point, Tex.	1.83	1.29	80
Power Development				
Lake Ianeycomo	Branson, Mo	4,610	2.06	50
Recreation				
Ardmore Club Lake	Ardmore, Okla	4.15	.55	180
Lake Bennet	Conway, Ark	4.16	2.20	50
Irrigation				
Lake Medina	San Antonio Tex.	587	.08	1250

APPENDIX—II

Reservoir drainage basins in U.S.A. in which sedimentation data indicates erosion rates of more than 1 inch per 40 years.

Reservoir	*River*	*Locailty*	*Drainage area*	*Age* (*rounded*)	*Accumulation of silt per annum in C. ft. per acre of drainage area*	*Time required for erosion of 1" of soil from drainage area*
			Sq. Miles	*Years*	(C.Ft.)	(Yrs)
Greenbelt Lake	Unnamed Creek	Greenbelt Md	1	2	624	6
Lake Concord	Coldwater Creek	Kannapolis N.C.	3	10	145	25
Ocoee No. 1	Ocoee River	Parksville Ten	600	19	126	29
Lake Bracken	Brish Creek	Galesburg Ill	9	13	137	27
West Frankfort	Tilly Creek	West Frankfort Ill	4	10	182	20
Pine Lake	Pine Creek	Eldora Iowa	15	8	103	35
Lake Bennet	East Fork Creek	Conway, Ark	4	Small	179	20
Mission Lake	Mission Creek	Horton, Kans	11	13	136	27
Lake Olathe	Cedar Creek	Okathe Kans	6	5	125	29
Ardmore Club Lake	Unnamed Creek	Ardmore, Okla	4	16	172	21

1	2	3		4	5	6
Boomer Lake	Boomer Creek	Stillwater, Okla	10	10	131	28
Guthrie	Cottonwood Creek	Guthrie Okla	13	15	165	22
Lake Gibbons	Pine Creek	Paris, Tex.	1	36	117	31
Rogers Municipal	Little River	Rogers, Tex.	1	12	414	9
White Rock Lake	White Rock Creek	Dallas, Tex.	112	25	109	33
Baker	Sandstone Creek	Baker, Mont.	5	29	119	30
Lake Ghabot	San Leandro Creek	Oakland Calif	42	48	118	31
Live Oak	Live Oak Creek	San Diego Country Calif	2	2	381	10
Morena	Cottonwood Creek	San Diego Country Calif	109	26	174	21
Santa Anita	Big Santa Anita Creek	Loss Angeles Country Calif	11	10	222	16
Upper Crystal Springs	Laguna Creek	San Francis Calif	8	8	148	25

APPENDIX—III

Statement showing rate of silting in reservoirs (in different States in U.S.A.) used for water supply or recreation.

State: Abbreviated name	*Name of Reservoir*	*Primary Use*	*Annual Loss %*	*Life in years (correct to nearest 10) before complete silting up*
MD	Burnt Mills	Water Supply	5.96	20
ILL	Cathoun	Recreation	4.37	20
TEX	Waco	Water Supply	3.34	30
PA	Palington	Water Supply	3.03	30
KANS	Olathe	Water Supply	2.11	50
SC	Spartanburg	Water Supply	2.09	50
MO	Grishan	Recreation	2.07	50
TEX	Rogers	Water Supply	1.91	50
NEBR	Wellfleet	Recreation	1.89	50
S. DAK	Hayes	Recreation	1.86	50
NG	Lee	Water Supply	1.85	50
CALIF	Gibraltar	Water Supply	1.83	60
S.C.	Lancaster	Water Supply	1.60	60
N. C.	Franklinton	Water Supply	1.60	60
TEX	Texas Pacific	Water Supply	1.51	70
OKLA	Clinton	Water Supply	1.33	70
TEX	Wills Point	Water Supply	1.29	70
KANS	Mission	Water Supply	1.20	80
MONT	Baker	Water Supply	1.15	90
N. C.	University	Water Supply	1.14	90
N. C.	Burlington	Water Supply	1.10	90
OKLA	Guthrie	Water Supply	1.03	100
ILL	Decatur	Water Supply	1.00	100
KANS	Santa Fe	Water Supply	0.98	100
OKLA	Claremore	Water Supply	0.98	100
N. C.	Lexington	Water Supply	0.97	100
KANS	Meade Co State	Recreation	0.92	110
KANS	Kirk	Recreation	0.91	110
N. C.	High Point	Water Supply	0.87	110
TEX	White Rock	Water Supply	0.86	120
ALA	Bayview	Water Supply	0.81	120
ILL	West Frankfort	Water Supply	0.81	120
NC	Greensboro	Water Supply	0.79	120

1	2	3	4	5
KANS	Ottawa Co State	Recreation	0.89	110
MO	Shephard MTN	Recreation	0.78	130
OKLA	Sapulpa	Water Supply	0.74	130
TEX	Dallas	Water Supply	0.72	140
KANS	Moran	Water Supply	0.69	140
S. DAK	Hurley	Recreation	0.67	150
N. C.	Concord	Water Supply	0.65	160
ILL	Bracken	Water Supply	0.60	170
OKLA	Boomer	Water Supply	0.59	170
OKLA	Ardmore	Recreation	0.55	180
TEX	Crook	Water Supply	0.49	200
TEX	Merrit	Water Supply	0.48	210
KANS	Eldrado	Recreation	0.45	220
CALIF	Morena	Water Supply	0.41	250
MO	Mountain	Water Supply	0.45	220
ARK	Booneville	Water Supply	0.40	250
TEX	Scarborough	Water Supply	0.40	250
N. C.	Salem	Water Supply	0.39	250
N. C.	Muche	Water Supply	0.36	280
KANS	Neosho Co State	Recreation	0.35	290
OKLA	Spavinaw	Water Supply	0.34	290
TEX	Grand Salie	Water Supply	0.31	320
CALIF	Hodges	Water Supply	0.29	350
ALA	Harris	Water Supply	0.29	350
VA	Barcroft	Water Supply	0.20	500
TEX	Santa Ana	Water Supply	0.16	620
TEX	Gibbons	Water Supply	0.15	620
ALA	Purdy	Water Supply	0.10	1000
CALIF	Upper Crystal Spring	Water Supply	0.06	1660
CALIF	Upper San Leandro	Water Supply	0.05	2000

SILTING OF RESERVOIRS : Statement V. H.

Statement of Reservoirs: Information extracted from C.B.I.P. No. 51

Very High Silt Deposit
(9 Cases)

S. No. CBIP No. 51	*Name of Reservoir*	*State*	*Annual Silt per Sq Mile. (C. Ft.)*	*Catch-ment Area Sq. Miles*	*Contents M.C. Ft.*	*% Run-off*	*Geology or Nature of Rock Soil*	*Croppting*	*Slope*
170	Conch Bhanwar	U.P.	1,30,000	2.7	30	64	n.g.	n.g.	n.g.
171	Bara Tal	U.P.	1,80,000	2.0	40	113	n.g.	n.g.	n.g.
183	Kumhari	M.P.	1,80,000	11.7	400	73	n.g.	M.	M.
186	Kusrangi	M.P.	1,00,000	5.9	160	54	Soft	Part	Flat
191	Mukardehi	M.P.	1,20,000	3.7	90	32	Soft	Part	Flat
198	Jam Mohgaon	M.P.	1,15,000	2.5	60	34	Soft	Cropped	Flat
206	Khor Tora	M.P.	1,18,000	1.0	15	34	Soft	n.g.	M
208	Sorli	M.P.	1,17,000	0.7	15	39	Soft	Partly	M
Nil	Boyal Marchand	Hyderabad	1,60,000	163.0	260	n.g.	n.g.	n.g.	n.g.

Note : M in col. 8 denotes Medium in hardness ; M in col. 9 denotes Cropped Area not too small nor too large ; M in col. 10 denotes neither flat nor steep. These are rough indications, being brief extracts from the original. This explanation is also applicable to the three tables following it.

Statement H

Statement of Reservoirs: information extracted from C.B.I.P. No. 51

High Silt Deposit

(15 *Cases*)

S. No. C.B.I.P. No. 51	*Name of Reservoir*	*State*	*Annual Silt per Sq. Mile. (C. Ft.)*	*Catch-ment Area Sq. Miles*	*Contents M.C Ft.*	*% Run-off*	*Geology or Nature of Rock Soil etc.*	*Cropping*	*Slope*
149	Lake Fife (Khadakwasla)	Bombay	61,000	196	3,900	n.g.	Hilly	n.g.	n.g.
150	Visapur	Bombay	66,000	159	1,200	n.g.	Black Soil	n.g.	n.g.
151	Ekruk	Bombay	64,000	159	3,200	n.g.	BlackSoil	n.g.	n.g.
159	Pingli	Bombay	69,000	20	200	High	Black Soil	n.g.	n.g.
160	Koregaon	Bombay	92,000	7	100	n.g.	n.g.	n.g.	n.g.
176	Sarathi	M.P.	95,000	37.8	570	46	Disintegral Crystaline	n.g.	Steep
178	Bodalkasse	M.P.	75,000	23.5	700	39	Dharwar	n.g.	Fairly Steep
179	Bori	M.P.	50,000	20.6	350	44	n.g.	Jungle	Steep
185	Khaira Datan	M.P.	80,000	7.5	80	19	Soft	Partly	Flat
193	Baloda	M.P.	90,000	3.6	40	27	Soft	n.g.	Flat
197	Kirna	M.P.	71,000	2.9	90	68	Soft	n.g.	Steep
199	Morid	M.P.	70,000	2.5	20	14	Soft	n.g.	Steep
200	Doongar Bari	M.P.	70,000	2.4	90	16	Soft	Wooded	Steep
205	Barapali	M.P.	70,000	1.0	30	60	M	Cropped	Moderate
Nil	Pocharam	Hyderabad	68,000	240	2,200	n.g.	n.g.	n.g.	n.g.

Statement L

Statement of Reservoirs: information extracted from C.B.I. P. No. 51

Low Silt Deposit

(25 Cases)

S. No. C.B.I.P. No. 51	*Name of Reservoir*	*State*	*Annual Silt per Sq. Mile. (C. Ft.)*	*Catch-ment Area Sq. Miles*	*Contents M.C.Ft.*	*% Run-off*	*Geology or Nature of Rock Soil etc.*	*Cropping*	*Slope*
148	Mheswad	Bombay	40,000	480	2,600	n.g	Good Soil	n.g.	n.g.
152	Lake Beale	Bombay	14,000	156	7,800	31	Rocky & Hilly	n.g.	n.g.
153	Nehr	Bombay	27,000	60	490	n.g.	Black Soil	n.g.	n.g.
154	Mayani	Bombay	44,000	52	190	n.g.	Good Soil	n.g.	n.g.
155	Mukti Tank	Bombay	11,000	34	340	n.g.	Hilly Catchment	n.g.	n.g.
156	Muchkundi	Bombay	30,000	26	650	high	Black Soil	n.g.	n.g.
157	Pimpalgaon	Bombay	17,000	24	200	n.g.	n.g.	n.g.	n.g.
158	Matoba	Bombay	30,000	20	230	n.g.	n.g.	n.g.	n.g.
166	Pahari	U.P.	12,000	3,000	1,600	1.3	n.g.	Cropped	n.g.
173	Manyari	M.P.	13,000	310	5,200	51	M.	Jungle	S
174	Kharang	M.P.	17,000	237	6,800	68	M.	Jungle	M
177	Charkhamare	M.P.	22,000	29.0	800	84	Dharwar	n.g.	Flat
181	Khapri	M.P.	10,000	15.4	400	57	M.	n.g.	M.
182	Jamunia	M.P.	27,000	11.8	320	77	Cryst	Wooded	Steep
187	Doritala	M.P.	23,000	5.5	80	33	Moder	Partly	Steep
188	Moroda (A)	M.P.	29,000	5.2	160	68	Rock	n.g.	Steep
189	Wara Tank	M.P.	31,000	4.4	100	21	Rock	n.g.	Steep
190	Dhanras	M.P.	18,000	4.0	50	28	Rock	n.g.	Steep
192	Borikheda	M.P.	17,000	3.7	40	48	Cryst.	n.g.	Steep
195	Hargahan	M.P.	30,000	3.2	110	75	M	Partly	M.
196	Amachna	M.P.	40,000	3.2	60	51	n.g.	n.g.	n.g.
201	Gomdoh	M.P.	27,000	1.7	50	72	Soft	Jungle	Flat
203	Dorli	M.P.	40,000	1.4	40	54	Soft	n.g.	Flat
204	Usri	M.P.	26,000	1.4	10	25	Cryst		Flat
209	Sayaji Sarovar	Baroda	31,000	36.2	2600	71	n.g.	n.g.	n.g.

Continued on page 30

Machkund Hydro-Electric Project

By

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AUTHOR

The Machkund power house is situated in the Koraput district of Orissa State, 120 miles by road from Visakhapatnam via Ananthagiri Ghats, Araku valley in Andhra and Padwa in Orissa. It is also accessible by road from Bobbili via Salur in Andhra and Koraput and Jeypore in Orissa, a distance of again 120 miles.

Project and its Genesis

The "Duduma Falls" with a drop of 550 ft. on the Machkund River are harnessed. This river is one of the sub-tributaries of the Godavary. In the composite Madras State prior to the partition of Orissa, surveys of hydro-electric potentialities were carried out in 1929 and a comprehensive report drawn up in 1931 by Sir Henry Howard. With the formation of the Orissa State in 1936, Machkund river became the boundary for Madras and Orissa near the project site. The Machkund hydro-electric project is a joint venture of Orissa and Andhra. Although jointly owned, it is being constructed under the direction and supervision of the Andhra Government Electricity Department.

The ultimate power potential is 1,02,000 k.W. Half this capacity viz. 51,000 k.W. is installed in the 1st stage. The power benefit and capital cost are shared by Andhra and Orissa in the ratio 70 : 30. The 132KV transmission lines from the joint power station are, however, constructed by the individual states.

Project Works

The first stage development comprises :—

(1) A main storage dam at Jalaput on the Machkund river, with a gross capacity of 25,650 M.Cft. and a net capacity of 25,400 M.Cft.

(2) A diversion dam across the river, 14 miles below Jalaput dam and 1½ miles above the Duduma falls with an effective storage of 389 M.Cft.

(3) Water conductor system consists of :
- (a) concrete lined flume channel 4034 ft. long.
- (b) Flume tunnel 4014 ft. long and lined with concrete.
- (c) Tunnel pond dam with forbay of 0.864 M.Cft.
- (d) Pressure Tunnel 2940 ft. long, lined with concrete.
- (e) Surge shaft 50 ft. diameter and 75 ft. deep.
- (f) Three penstock pipes each 1504 ft. with haulage track of 2150 ft. long.

(4) Power house with three units each of 17,000kW capacity with space provision for three more units in the second stage.

Jalaput Dam

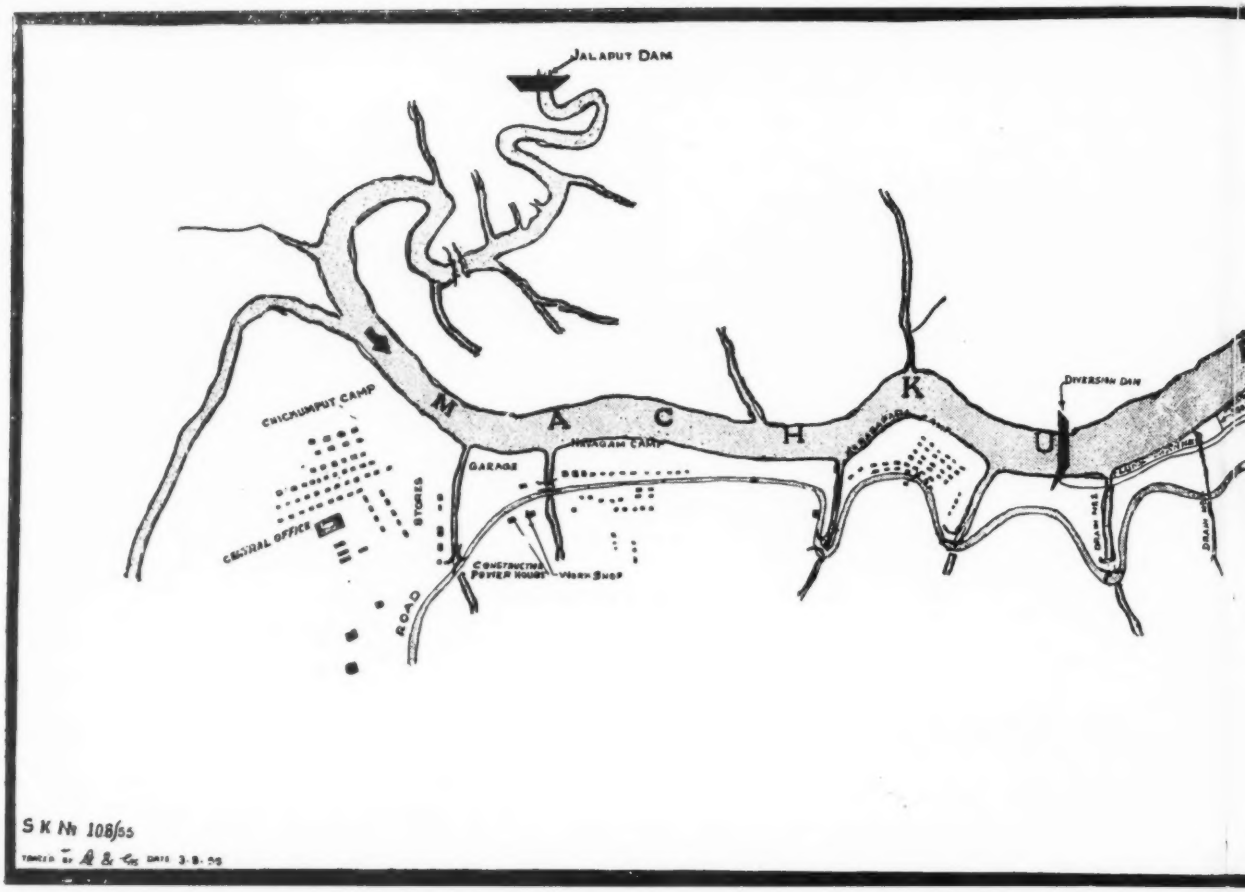
The Jalaput Dam now under construction forms the main storage reservoir for the Machkund hydro-electric scheme. It is located about 1½ miles below the confluence of Machkund and its chief tributary the Pathala. Work on this dam is expected to be completed by the end of 1957. The dam is 1220 ft. long, with top width of 18 ft. and a maximum height of 148 ft. above the deepest bed level. The volumetric content of masonry is about 12.5 million cubic feet. The free catchment is 755 sq. miles yielding a continuous power draft of 1125 cusecs. Three steel discharge pipes each 8′-6″ diameter are being embedded in this dam. These will be also used later to develop a maximum power of 20,000 kW. Two scour pipes 8′-6″ diameter are provided near the power pipes to keep the intakes clear of silt.

The Jalaput surplus will be located in the saddle on the right flank. The length of the spillway is 550 ft. with eight gates of 60′×20′ to discharge a maximum flood of 1,49,000 cusecs.

The Machkund water are charged with silt mainly due to the wasteful method of "podu" cultivation practised by the hill tribes. This problem is being effectively tackled by preventive measures, afforestation, and adopting silt exclusion devices in the design of the dam.

Diversion Dam

It is completed except for the erection of the gates in the spillway portion. The dam is 925 ft. long and is of a gravity type in solid masonry with a central



Machkund Hydro-

spillway 560′ long with 8 nos. 60′×20′ crest gates designed to pass a maximum flood discharge of 1,85,000 cusecs. Two sluices 12′×8′ each (peak discharge 1800 cusecs each) for the intake of the flume and one scour sluice 12′×8′ are located at the right flank. The cubic contents of the masonry is about 2 million cubic feet. This diversion dam will provide a storage of 389 M.Cft. for regulating and balancing purposes.

Flume and Tunnels

The water from the diversion dam is drawn through intake gates and conducted partly along an open concrete lined flume about 4034 ft. long, (including 334′ of aqueduct) skirting the hill slopes on the right bank of the river. Next comes the free flow tunnel about 4014 ft. in length with a sectional area of 238 sq. ft. capable of handling 1800 cusecs peak discharge. Water from this flume tunnel discharges into the Makkiput valley where a regulating pond is formed by the "Tunnel Pond Dam", about 442 ft. long and 60 ft. high above the bed, with an effective capacity about one M.Cft. at full reservoir level.

From the tunnel pond, water is conveyed through intake controls into a concrete lined pressure tunnel, approximately 2940 ft. long of 'horse-shoe' shape with a sectional area of 185 sq. ft.

Surge Shaft

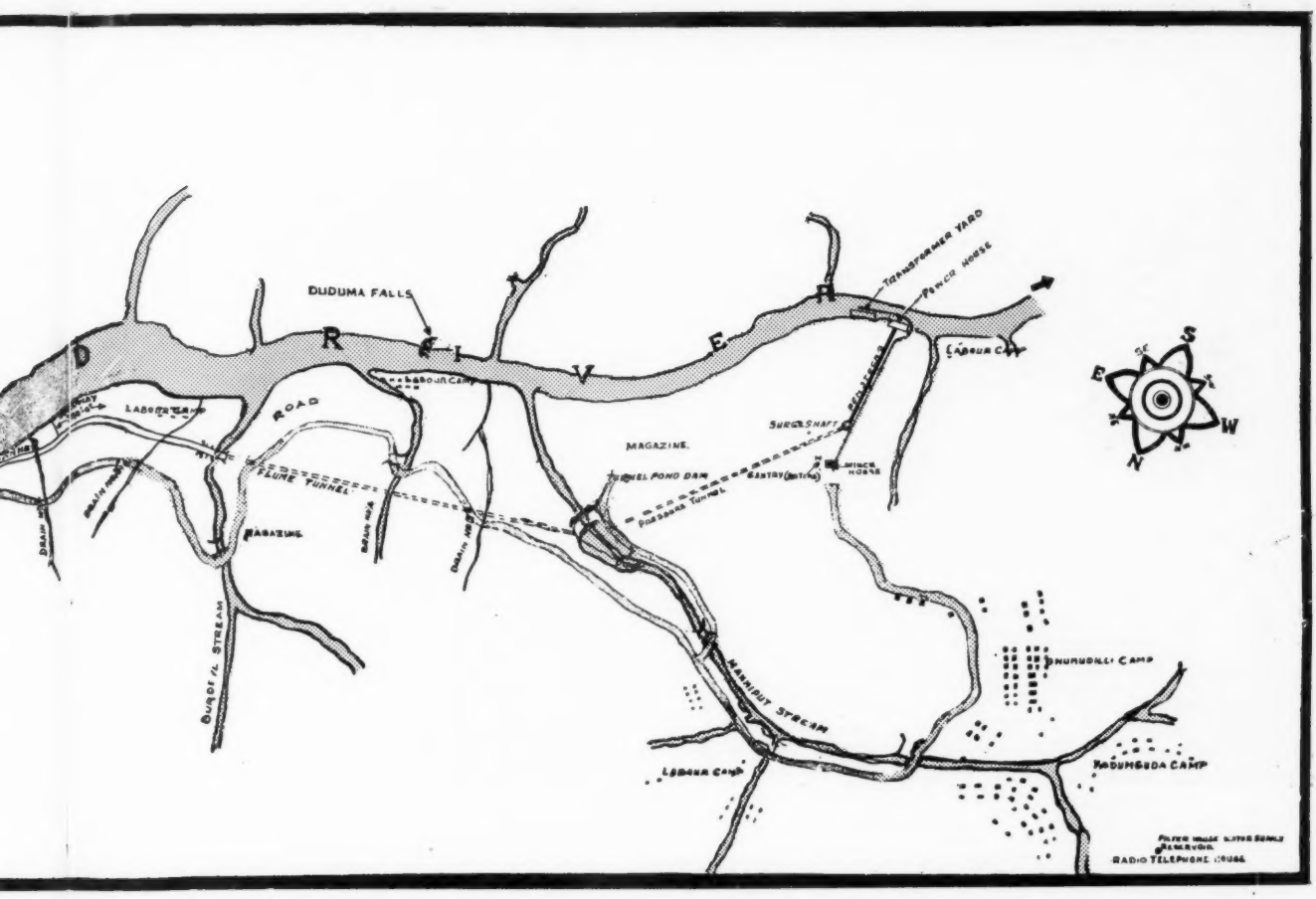
The pressure tunnel ends in a surge shaft 50 ft. internal diameter and 75 ft. deep, excavated in rock and lined with concrete. From the surge shaft, two steel pipes, each of 10 ft. diameter laid for a distance of 140 ft. in a pipe tunnel, terminate into a three-way manifold, 66ft. long. From these manifolds, three penstocks run down to the power house, and the three pipes of the second manifold are closed with blank flanges for connection to future penstocks.

Penstocks

Each penstock pipe feeds a generating unit. The penstock pipe is about 1504′ long. 63″ dia. for a length of 770 ft, and 57″ dia. for a rest of the length. The shell thickness of pipe varies from 0.44″ to 1.56″.

At the head of the penstock and below the manifold, a butter fly valve 63″ diameter is provided. A high pressure valve 57″/48″ is also provided at the end of the penstock near the power house.

By the side of the penstocks, a haulage track



und Hydro-Electric Scheme

runs down to the power house for the transport of men and materials.

Power Station

The power house is a steel framed building with course rubble masonry walls in superstructure. The substructure provides for two floors, the turbine hall and the generator floor. A switchgear annexe with a cable trench underneath, adjoins the machine hall on the upstream side. The main building of the power house including the switchgear annexe is 295′×60-9″ to house six generating units with all their auxiliaries and a house service unit.

The sub-structure of the machine hall portion is of reinforced cement concrete walls, 6 ft. thick taken down to the foundations 46 ft. below the main floor level of the power house to suit the vertical type of the generating units. The generators are supported on independent r.c.c. slabs with beams on massive r.c.c. columns.

A 100-ton electrically operated overhead crane runs the full length of the machine hall to facilitate erection of the heavy machinery in the power house. The ground floor of the switchgear annexe accommodates all the 11 K.V. metal-clad switchgear and fire fighting and other associated equipment. From the main cable tunnel of the power house running the full length, connections are taken to 11 k.V. switchgear cubicles and to the outdoor yard. The main control panels, office and battery room are located on the first floor of the switchgear annexe. The cooling water and "Mulsifyre" pumps are located in a small extension at the eastern end of the power house below the ground floor level. The supply to the cooling water and "Mulsifyre" systems is taken from the tail race pool.

Generating sets

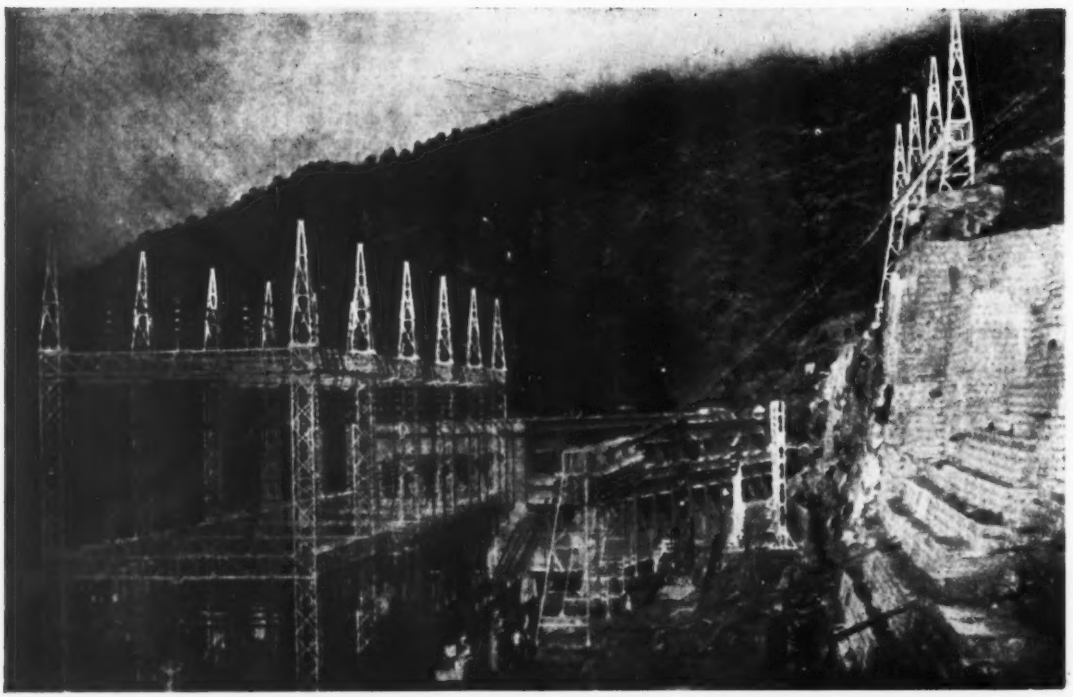
Each 17,000 k.W. generating unit is directly coupled to a 25,000 H.P. Francis vertical reaction type turbine. The voltage generated is stepped up from 11 K.V. to 132 K.V. through banks of single phase 6670 KVA transformers located in the outdoor yard and connected to the generators on the unit system. The machines are paralleled on the high voltage side.

A 500 KVA. capacity auxiliary generating set is installed for emergency use.

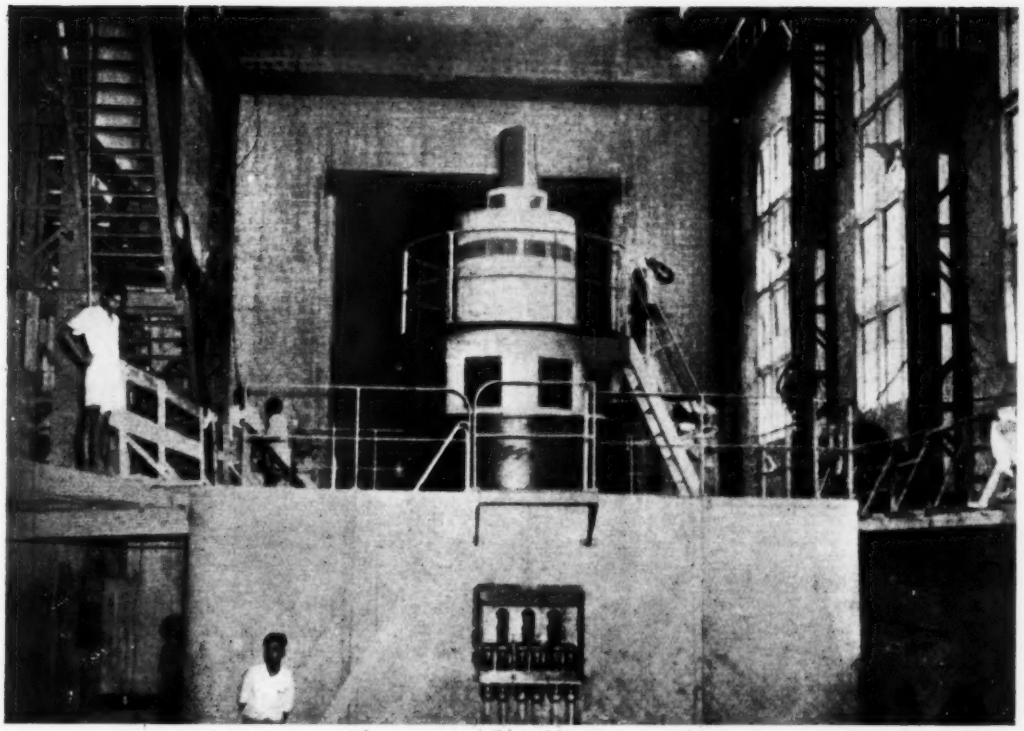
Transmission system (Andhra side)

The power generated at Machkund Power House

Flow Channel of Machkund Hydroelectric Project under execution.



Machkund Outdoor Switch and Transformer Yard.



Number I Generating Unit ready for Service.

is transmitted by a double circuit 132 KV transmission line as far as Nellore District about 450 miles from Machkund. The total mileage of 132 KV double circuit line is about 570 circuit miles and that of single circuit line about 200 miles. All 132 KV lines are on fabricated steel towers.

The transmission lines are routed so as to link up with the existing thermal stations at Visakhapatnam, Vijayawada and Nellore. The thermal stations are required to supplement the Machkund power till adequate water storage is made available by completing the Jalaput Dam. The thermal stations will remain as "standby" thereafter.

The salient particulars of the trunk lines fed by the Machkund hydro station are given below :

Machkund Hydro-Electric Scheme

DETAILS OF TRANSMISSION LINES

Transmission Line	*Voltage*	*Length*	*Power Conductor size*	*Copper Equivalent in sq. inch*
Machkund-Tennubodduvara-Visakhapatnam	132KV Double Circuit	90 miles	37/0.118 ACSR	0.20
Visakhapatnam-Rajahmundry-Bhimadole-Vijayawada	do	195 miles	37/0.110 ACSR	0.175
Vijayawada-Ongole	132KV Single Circuit	81 miles	6/0.186 plus 7/0.062 ACSR	0.10
Tennubodduvara-Nellimarla	do	23 miles	37/0.102 ACSR	0.15
Machkund-Jeypore-Rayaghada (Orrissa feeder)	do	92 miles	37/0.110 ACSR	0.175
Ongole-Nellore line	66KV Single Circuit line	75 miles	7/.144 A.C.S.R.	0.06

Grid substations

The power transmitted at 132 KV from Machkund will be stepped down to 33 and 11 KV for secondary transmission and distribution purposes at the following substations :—

Sub-Station :	*Installed transformrr capacity*
Nellimarla	12,000 K.V.A.
Simhachalam (near Visakhapatnam)	27,000 K.V.A.
Bommur (near Rajahmundry)	26,500 K.V.A.
Bhimadole	8,000 K.V.A.
Gunadala (near Vijayawada)	22,500 K.V.A.
Tadepalli	37,500 K.V.A.
Ongole	11,500 K.V.A.
Nellore	6,000 K.V.A.

The thermal station at Vishakapatnam is connected to the hydro electric system by double circuit 33 KV line from Simhachalam and that at Vijayawada by another 33 KV line from Gunadala hydro substation.

The following important places in the districts in Andhra State will be receiving power.

Srikakulam district	Srikakulam Garbham Bobbili Parvathipuram Narasannapeta Tekkali
Visakhapatnam district	Visakhapatnam Simhachalam Chittivalasa Bhimilipatnam Vijayanagaram Nellimarla Penubarthi Kasimkota
East Godavari district	Kakinada Rajahmundry Peddapuram Pithapuram Tuni Ramachandrapuram Amalapuram
West Godavari district	Eluru Bhimadole Nidadavole Palacole Narasapur Bhimavaram
Krishna district	Masulipatam Vijayaw .da Jaggayyapeta Vuyyuru Gudivada Nuzvid
Guntur district	Guntur Tenali Narasaraopet Bepatla Chirala Ongole Tadepalle
Nellore district	Nellore Gudur Nayudupet Sulurpet Venkatagiri

On the Orissa side, the districts of Koraput and Ganjam will get benefitted by Machkund Power. Power lines are being extended by Orissa State to Jeypore and Rayagada and later on to Berhampore thus covering the southern portion of the state.

Communications

In this modern era of industrial development reliable and uninterrupted supply of power is essential to avoid loss of production and dislocation of labour. To facilitate efficient system control and operation, carrier current communication has been installed. This is a unique feature introduced in South India for the first time. This system uses the power line conductors themselves for transmission of speech signals at high frequency without interfering with power transmission and has been working satisfactorily.

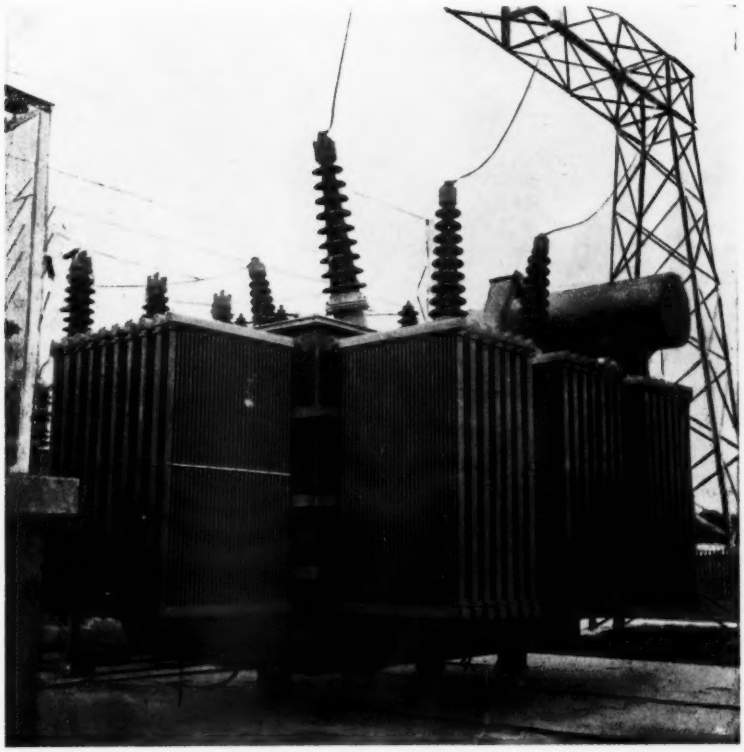
Condenser Station

At Bommur sub-station near Rajahmundry, there are 2 nos. 7500 KVA synchronous condensers for improving voltage regulation beyond Rajahmundry and also ensuring system stability.

Plant Manufacturers

Supplies of Plant and Machinery for the Machkund Scheme have been made by many well known foreign and Indian manufacturers, enumerated below:

1. Diversion dam gates and screens	M/s. Ramsome & Rapiers, England. (Director-General, India Store Dept., London).
2. Tunnel pond gates & screens	M/s. Dortmunder Union, Germany (M/s. Kamani Engineering Corporation Ltd., Bombay).
3. Winch and haulage track	M/s. Wild & Co., England. (Director-General, India Store Dept., London).
4. Haulage track materials	M/s. Robert Hudson & Co., England.
5. Penstocks.	M/s. Ferrums, Poland (Director-General, India Store Dept., London).
6. Butterfly valves	M/s. Boving & Co., England.
7. Turbine inlet valves	M/s. English Electric Co., England. (M/s. Binny & Co., Madras).



10 MVA 132/66 kV 3 phase
Transformer at Bareilly

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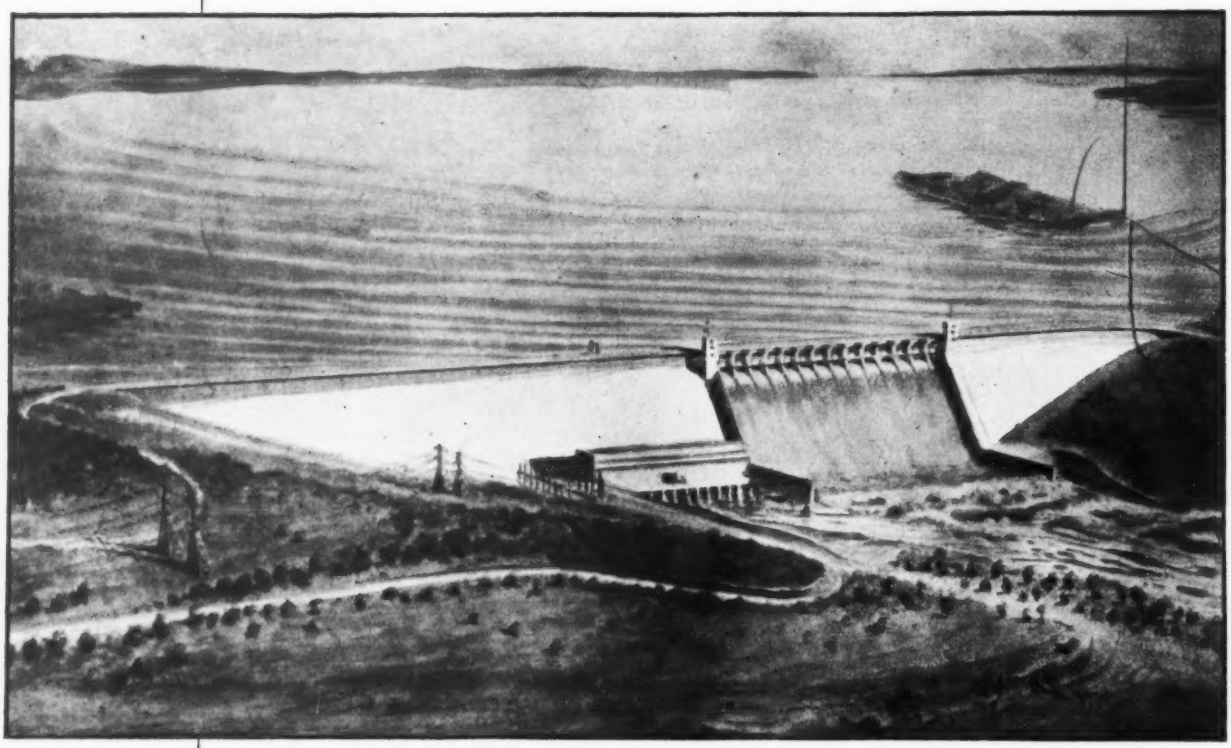

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11. Gates, screens and hoists for Jalaput dam.	M/s. Dortmunder, Union, Germany. (M/s. Kamani Engineering Corporation Ltd., Bombay).
12. Pipes for Jalaput dam.	M/s. Garlic & Co., Bombay.
13. Spillway gates and hoists for diversion dam & & Jalaput dam	Tungabhadra Dam Worksshops, Hospet.
14. Tunnels	M/s. John Mowlem & Co., England.
15. Power House, Diversion dam, flume channel, channel, Jalaput dam and Godavari river crossing piers.	M/s. Gannon Dunkerly & Co., & Ltd., Madras.
16. Tunnel pond dam, excavation of power house & transformer yard, tail race, penstock grading and Jalaput dam	M/s. G. S. Dugal & Co., Pooma.
17. Krishna River crossing piers.	M/s. Pioneer Construction Co., Vijayawada.
18. Generators and indoor switchgear.	M/s. Westinghouse International Trading Co., U.S.A. (M/s. Crompton Engineering Co., Ltd., Madras).
19. Power Transformers	M/s. Ferranti, England (M/s. British Insulated Callenders Cables Ltd., Madras).
20. Outdoor yard and switchgear	M/s. B.T.H. England (M/s. Associated Electrical Industries (India) Ltd., Calcutta).
21. Powerhouse Crane	M/s. Demag, Germany (M/s. Kamani Engineering Corporation Ltd., Bombay).
22. Power house steel work.	M/s. Chitram & Co., Madras.
23. Transmission lines.	M/s. British Insulated Callenders Cables Ltd., Madras.
	M/s. S.A.E., Italy and M/s. Crompton Engineering Co., Ltd., Madras.
24. Substations.	M/s. Crompton Engineering Co., Ltd., Madras.
	M/s. Reyrolle Agency, Calcutta.
	M/s. Associated Electrical Industries (India) Ltd., Calcutta.
	M/s. Easun Engineering Co., Ltd., Madras, and
	M/s. English Electric Co., Ltd., Madras.

Capital cost of the scheme

The details of the capital cost for the joint scheme and the entire scheme on the Andhra side are furnished below in a tabular statement. The Andhra share of capital cost works out to about Rs. 15 crores initially rising to about Rs. 19½ crores at the end of ten years.

Capital cost for the joint scheme and entire Andhra scheme

S. No.	*Particulars*	*Capital cost initial*	*At the end of 10 years*
		Amount in lakhs of rupees	
I. Joint Scheme			
	Joint scheme (Civil Works and power staton).	926.05	1356.93
	Andhra share of capital on joint scheme (70%).	648.23	949.85
	Orissa share of capital on joint scheme (30%)	277.82	407.08
II. Andhra Transmission Scheme :			
	Transmission lines	587.08	601.83
	Substations and 132 KV feeder control equipment at Machkund	272.40	293.96
	Thermal station	..	100.06
	Total for Andhra Transmission scheme	859.48	995.85
III. Overall Andhra share of Capital cost:		1507.71	1945.70

Load Prospects

It is gratifying to note that large blocks of power demands such as Caltex refinery at Visakhapatnam, Ferro-manganese industry at Garividi, Fertiliser factory sponsored by Government of India at Vijayawada and Cement factories at Vijayawada and Macheral are expected to come up soon and accelerate the bad development much faster than envisaged in the scheme load forecast.

Duduma Falls.

New record of Construction

The project site being 120 miles away from railhead accessible only through a road passing through difficult ghat section constitutes a unique transport problem. Scarcity of labour in this remote backward area, involving large scale import of labour, severe weather conditions limiting the working period to about 9 months in the year, incidence of malaria and other difficulties had to be overcome.

The target date of September 1956 for the commissioning of the first generating unit envisaged in the composite state of Madras, had to be advanced and construction schedules accelerated after the formation of the Andhra State due to lack of hydro power in the new born State. By working round the clock, new records were achieved. From foundations of the power house to completion of the first unit in 18 months is a gratifying progress. The first generating unit will by switched on by the President of India on August 19, 1955.

Conclusion

To the people of Andhra, Machkund signifies a big step forward heralding a new tempo of development of industries, agriculture, cottage and rural industries.

The first Five Year Plan for power projects for Andhra, culminating in the commissioning of the first stage of the Machkund hydro-electric scheme, is bound to quicken the pace of development in this new born state.

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Basis for Betterment Levy

C. S. PARTHASARATHY

Asst. Chief (Natural Resources), Planning Commission

AUTHOR

Most of the States in India have accepted the principle of the Goverment recovering, from the beneficiaries, a portion of the 'unearned' benefits that accrue to land, as a result of the completion of irrigation projects, through a capital tax styled "Betterment Levy". The principle has been recognised and affirmed by the National Deveolpment Council of which the Prime Minister of India is the Chairman and the State Chief Ministers, Members. On the basis of the progress so far made in respect of implementation of this principle, the various states may be categorised, broadly, as follows:—

I. States who have passed the necessary Acts :

1. Assam,
2. Bombay,
3. Punjab,
4. Hyderabad,
5. Mysore,
6. PEPSU.,
7. Rajasthan,
8. Madras.

II. States who have introduced Bills in their Legislatures:

9. Andhra,
10. Madhya Bharat,
11. Orissa.

III. States who have prepared the Bill and are taking action towards enactment:

12. Bihar,
13. West Bengal,
14. Saurashtra,
15. Travancore-Cochin,
16. Himachal Pradesh.

IV. States where the Bill is under preparation :

17. Madhya Pradesh.

V. States with whom the matter is under consideration:

18. Jammu & Kashmir,
19. Coorg,
20. Delhi,
21. Kutch,
22. Vindhya Pradesh.

VI. States where the question does not arise owing to absence of major river-valley schemes or absence of a suitable case for levy:

23. Ajmer,
24. Bhopal,
25. Manipur,
26. Tripura.

VII. State which has not accepted the principle so far:

27. Uttar Pradesh.

It may be added that Bombay and Punjab have provided in their 1955-56 Budgets for some revenues through betterment levy. The subject has been dealt with in

(*i*) paragraphs 57 to 67 of Chapter XXVI—Irrigation and Power — of the "First Five Year Plan", and

(*ii*) paragraphs 25—33 of Chapter VII of Volume III of the "Taxation Enquiry Commission, (1953-54) Report".

It will be seen from the preceding paragraph that Legislation has been passed in eight States and Bills have been prepared in eight other States including Himachal Pradesh (a Part 'C' State). The basis for evaluating the quantum of betterment levy proposed to be recovered from the beneficiaries by the Government, is a vital point and differs in different States, as will be evident from a perusal of Annexure I which portrays relevant extracts from the Acts and Bills of sixteen States mentioned in categories I,II and III of the preceding paragraph. The essence of Annexure I is compressed as Annexure II. A critical analysis of this brings out the fact that the quantum or amount of betterment levy has, generally speaking, been based on one or more of the following criteria:—

(*i*) Increase in the market value of land benefited between the date of commencement and the date of completion of the project ;

(*ii*) Difference between the market value of wet or irrigated and unirrigated or dry lands in the project-affected area or its vicinity after the completion of the project :

(*iii*) Increase in the value of land equated to a multiple of the increase in the value of agricultural produce over a period of one year;

(*iv*) Increase in the yield of the principal crops; and

(*v*) Recovery of a portion of the capital cost of a project.

Other factors viz., quality of soil expenditure involved in converting dry into wet land, type of irrigation etc., have generally been kept in view, and the proposed recovery is a certain fraction of the extra unearned benefits in different States. The basis for criteria (i) and (ii) above is the calculation of the market value. In respect of criterion (i), the comparision is between the market value of land benefited between the date of commencement and the date of completion of a project and, in the second, between the market value of irrigated and unirrigated land in the project area or in its vicinity just before levy commences. Similarly the third and the fourth essentially hinge on difference in yield between land which is irrigated and land which is unirrigated and are, therefore, easy and intelligible. The hidden fact is that the second, third and fourth principles represent but different aspects of the same phonomenon, namely, the resultant increase in productivity of land arising from, or due to, irrigation facilities afforded by a project.

The basis of increase in value of land between a date connected with the date of commencement of construction and a date depending on the date of completion of the project, has the disadvantage that the ratios between the two rates obtaining on the two distant dates may be considerably affected by changes in rates of agricultural produce and consequent money values in the intervening period. Reforms in proprietory and tenancy laws may also affect the market values of the land, and the difference between these values over a period of years may not have a correct relationship between the benefits derived by such lands. It appears that a levy based on the difference in value or agricultural produce between two different dates will also suffer from the same lacuna.

My grateful thanks are due to Shri Yadav Mohan, I.S.E. Chief (Natural Resources), Planning Commission, for his valuable advice and suggestions. The permission to publish this paper in this Journal is also thankfully acknowledged.

Annexure I—Basis for Betterment Levy

(*Extracts from State Acts and Bills*)

No	*State*	*Name of Act/Bill*	*Clause No.*	*Basis*
1	2	3	4	5
				ACTS
1.	Assam	The Assam Embankment and Drainage Act, 1953.	11	*Levy of rates, cess and premium* 11. For all works carried out under section 9 the State Government may, unless they decide otherwise in specific cases, levy on settled land an annual water rate or betterment cess and on unsettled Government waste land improved by the works, a premium payable on settlement of such land, and an annual water rate or betterment cess, so as to realise the initial cost of the Scheme in full or in part and that of its maintenance in the manner as Government may prescribe. The total annual water rate, betterment cess or premiumm to be levied under a scheme shall be fixed as nearly as possible so as not to exceed the following limits:— (i) Six per cent per annum on the first cost of the said works adding thereto the estimated yearly cost of maintenance and supervision of the same. (ii) Such rate may be varied from time to time within such maximum by the State Government.
2.	Bombay	The Bombay Irrigation Act, 1879 as amended	52	*Increase in value and betterment Charge* : 52. The increase in value on account of the completion of a new canal or the improvement or extentsion of an existing canal shall be the amount by which the value of the land on the completion date is likely to exceed the value of the land on the construction date and the betterment charges shall be one-half of such increase in value.

1	2	3	4	5
				Explanation—For the purposes of this section the Statement shall, by notification in the Official Gazette, specify— (a) the date of the commencement of construction of any work in connection with the construction or improvement or extension of canal, as the construction date ; (h) the date of completion of the construction, improvement or extension of a canal as the completion date.
3.	Punjab	Punjab Betterment Charges and Acreage Rates Act, 1952	5(1) &(2)	5. *Amount of betterment charges* : (1) The amount of the betterment charges leviable in respect of any lands included in an irrigation scheme shall not exceed one-half of the lands with reference to such date prior to the commencement of any work in connection with the irrigation scheme as the Government may, by notification in the Official Gazette, fix in this behalf and their estimated value with reference to such other date after such commencement as the Government may similarly fix, and such valuations shall be made in the prescribed manner. (2) Where in an irrigation scheme only lift irrigation arrangements are maintained and operated by the landowners or occupancy tenants the betterment charges leviable shall not exceed one-half of the charges which would otherwise have been payable for gravity flow irrigation : Provided that whenever such lift irrigation arrangements are converted into gravity flow irrigation, the landowners or occupancy tenants as the case may be, shall be liable to pay the full betterment charges in respect of the lands.
4.	Pepsu	The Pepsu Betterment Charges and Acreage Rates Act, 1953.	5(1) &(2)	(The same wording as in Punjab Act (above)
5.	Rajasthan	The Rajasthan lands Special Irrigation Charges Bill, (8), 1953 (1952) (9)	5(7)	5(7) The amount of the betterment fees leviable in respect of any lands included in an irrigation scheme shall not exceed one-half of the difference between the value of the lands with reference to such date prior to the commencement of any work in connection with the irrigation scheme as the Government may by notification in the Rajasthan Gazette, fix in this behalf and their situated value with reference to such other date after such commencement as the Government similarly fix, and such valuations shall be made in the prescribed manner. (8) Where in an irrigation scheme only lift irrigation arrangements are maintained and operated by the land-holders or occupancy tenants, the betterment fees leviable shall not exceed one-half of the fees which would otherwise have been payable for gravity flow irrigation. (9) Whenever such lift irrigation arrangements are converted into gravity flow irrigation, the land-holders or occupancy tenants, as the case may be, shall be liable to pay the full betterment fees in respect of the lands.

1	2	3	4	5
6.	Mysore	(Mysore Irrigation (Amendment Act, 1952 1952)—Clause 29(1) Clause 4(4).	29(1)	The scheme as finally approved by the Government shall be published in the Official Gazette, and it shall embody the following particulars:—
			2 (a) (b) & (c)	2 (a) a description of the benefitted area ; (b) the rates at which contribution will be recovered in the lands in the benefitted area and terms of such recovery. and (c) the rates at which water rates will be imposed on the lands in the benefitted area.
			1 (2)	1(2) The contribution referred to in clause (b) of sub-section (1) shall not in the case of restoration or improvement of any minor tank exceed two hundred rupees per acre in respect of the lands in the benefited area.
			Amendment clause 4(4)	Where the betterment tax referred to in clause (b) of sub-section (1) exceeds five hundred rupees per acre or the water rate referred to in clause (c) of sub-section (1) or the water rate as revised under sub-section (3), exceeds twenty rupees per acre per annum the scheme or order as published in the Official Gazette under sub-section(3) shall be laid before the Mysore legislative assembly as soon as may be after it is published in the official gazette, and the rate of betterment tax or water rate specified in such schemes or order shall be subject to such modifications as the said Legislative Assembly may make on a motion made within seven days from date on which the scheme or order, as the case may be, is so laid.
7.	Hyderabad	The Hyderabad Irrigation Act, 1952.	5 & 6	5. For the purpose of assessing the contribution, the Committee shall take into consideration the following factors : (i) The market rate of dry land in the area or its vicinity ; (ii) The market rate of wet land in the area or its vicinity ; (iii) Nature of the soil, productivity and fitness for irrigation ; (iv) The wet crops that can be grown economically ; (v) Its proximity to market, village, road, etc. (vi) The probable expenditure to be incurred in converting the dry land into wet; (vii) The classification of land, whether perennial garden or light irrigated in accordance with the cropping scheme sanctioned by the Government for the particular irrigation work.
				6. The contribution determined for any land shall in no case exceed one-half of the net increase in capital value of the land in the case of new lands served by the irrigation work and one-fourth in the case of old wet lands.
8.	Madras	Madras Irrigation (Levy of Betterment Contribution) Act, 1955	4.	*Amount of betterment contributions* :— (1) The lands benefited by the construction, expansion or alteration of any work shall be divided into suitable classes by the Government and the annual increase in the gross produce of each class of lands shall be estimated :

1	2	3	4	5
				Provided that all lands which are of the same terrain and which, judged by their commandability, are so situated as to derive the same amount of benefit from the work shall be placed in the same class : Provided further that the estimate shall be made with reference to the average of the prices prevailing, in the case of a work whose constructon, expansion or alteration was completed before the commencement of this Act, during the three years immediately preceding commencement and, in the case of a work whose construction, expansion or alteration was completed after the commencement of this Act, during the three years immediately preceding such completion : Provided also that the average aforesaid shall not exceed three times the price which prevailed in August 1939. (2) Ten times the annual increase in the gross produce estimated under sub-section (1) shall be deemed to be the increase in the capital value of each class of lands ; and the contribution payable in respect of such class of lands shall be one-half of the difference between the said increase in the capital value and the cost (estimated in the prescribed manner) of making the lands fit for advantageous irrigation under the work : Provided that in the case of lands which were originally under dry cultivation and which, with a view to derive benefit from the work, were brought under wet cultivation, a sum representing the difference between the cost of wet cultivation and the cost of dry cultivation as determined in the prescribed manner shall be deducted from the increase in gross produce for the purpose of calculating the increase in capital value of those lands.
		BILLS		
9.	Andhra	The Andhra Irrigation (Levy of Betterment contribution) Bill, 1954.	4	*Amount of betterment contribution*:— (1) The lands benefited or capable of being benefited, by the construction, expansion or alteration of any work shall be divided into several classes by the Government according to the nature and quality of soils, physical configuration and the extent of reclamation required to bring the lands to advantageous cultivation under the work after its construction, expansion or alteration and the amount of the net additional annual income derived, by the owners of the lands as a result of the work should be calculated in the prescribed manner for each class of lands with reference to the prices prevailing on the date of the completion of the work, which shall be notified in the Andhra Gazette. (2) Twenty-five times the net additional income aforesaid minus the expenses incurred or likely to be incurred by the owners for making the lands fit for advantageous cultivation under the work after its construction, expansion or alteration, shall be deemed to be the increase in the capital value of each class of land;

1	2	3	4	5
				and the betterment contribution leviable in respect thereof shall be fixed so as not to exceed one-half of such increase.
10.	Travancore-Cochin	The Travancore Cochin Irrigation (Levy of Betterment Contribution and Water Cess) Bill, 1955.	4(1), (2) & (3)	4. *Amount of betterment contribution* :— (1) The lands benefited by the construction, expansion or alteration of any major irrigation work or lift irrigation work shall be divided into suitable classes by the Government and the annual increase in the gross produce of each class of lands consequent on the provisons of irrigation facilities shall be estimated: Provided that all lands which are of the same terrain and which, judged by their commandability, are so situated as to derive the same amount of benefit from the work shall be placed in the same class. (2) The annual increase in the gross produce shall be estimated with reference to the average of the prices prevailing during the fifteen years immediately preceding the date of making such estimate. (3) Twenty times the annual increase in the gross produce estimated under sub-section (1) shall be deemed to be the increase in the capital value of each class of lands ; and one-fourth of the sum by which the said increase in the capital value exceeds the cost (estimated in the prescribed manner) of making the lands fit for advantageous irrigation under the major irrigation work or lift irrigation work shall be the contribution payable in respect of such class of lands.
11.	Orissa	The Orissa Betterment Charges Bill, 1954	(3)	3. There shall be levied on every land under irrigable Command betterment charge in accordance with the rates specified in Schedule A (below). SCHEDULE A (*See Section* 3) *Betterment Charges to be levied on Lands under Irrigable Command* (a) Sambalpur Zone — Betterment charges shall be levied on the following scale :—

Item	*Classification of land*	*Betterment per acre Charges* Rs.
(i)	Bahal lands	60
(ii)	Barchha lands	75
(iii)	Berna land	75
(iv)	Bari land	75
(v)	Mal land	100
(vi)	"At" land	60

The classification of land will be its classification on a date notified by the State Government prior to the provision of irrigation under the scheme under the principles enunciated in the Settlement record for the lands in question.

12.	West Bengal	The West Bengal Development (Levies)	(11)	*Estimate of increase in the capital value of land.* 11. (1) From time to time an officer appointted by

1	2	3	4	5
		and Miscellaneous Provisions) Bill, 1954.		the State Government shall, after hearing any objections in the manner prescribed by rules, prepare, in respect of land throughout a notified area, an estimate of the capital value of such land which, in his opinion, has resulted or is likely to result from the execution of any development scheme: Provided that in respect of any agricultural land such increase shall be the amount by which the value of the land on the date of completion of the development scheme is likely to exceed the value of the land on the date of the commencement of execution of the development scheme : Provided further, that such agricultural land shall be the amount by which the value of the land on the completion of the execution of the development scheme, estimated as if the land were clear of buildings, exceeds the value of the land prior to the execution of the scheme estimated in like manner. *Explanation* :—For the purposes of this sub-section the State Government shall, after considering the circumstances, by notification, specify (a) the date of commencement of the execution of any development scheme, and (b) the date of completion of the execution of any development scheme.
13.	Saurashtra	Draft Bill (1954) to amend the Saurashtra Irrigation Act of 1951	6-D	(1) The betterment charges shall be leviable at a rate not less than Rs. 100/- per acre and not more than Rs. 150/- per acre for land under irrigation of a canal. The exact levy of betterment charges per acre . . . . . shall take into consideration the increase in value of such land by the completion of the construc- of a new canal or the improvement or the extension of an existing canal, the irrigation facilities available and the nature of the land.
14.	Madhya Bharat	The Madhya Bharat Betterment Charges and Acreage Rates Bill, 1954	5(1) &(2)	5. (1) The amount of the betterment charges leviable in respect of any lands included in an irrigation scheme shall not exceed one-half of the difference between the value of the lands with reference to such date prior to the commencement of any work in connection with irrigation scheme as the Government may, by notification in the Gazette, fix in this behalf and their estimated value with reference to such other date after such commencement as the Government may similarly fix, and such valuations shall be made in the prescribed manner. (2) Where in an irrigation scheme only lift irrigation arrangements are maintained and operated by the land holder, the betterment charges leviable shall not exceed one-half of the charges which would otherwise have been payable for gravity flow irrigation : Provided that whenever such lift irrigation arrangements are converted into gravity flow irrigation, the land holder shall be liable to pay the full betterment charges in respect of the lands.

1.	2	3	4	5
15.	Bihar	The Bihar River-Valley (Multi-purposes Projects) Bill,1954.	(23)	23. The increase in value on account of the completion of a new canal or the improvement or extension of an existing canal shall be the amount which the value of the land on the completion date is likely to exceed the value of the land on the construction date and the betterment charges shall not exceed one-half of such increase in value. *Explanation* :—For the purpose of this section the State Government shall by notification in the Official Gazette specify :— (a) the date of the commencement of construction of improvement or extension of a canal as the construction date ; (b) the date of completion of the construction, improvement or extension of a canal as the completion date.
16.	Himachal Pradesh	The Himachal Pradesh Minor Canals Bill	9(1)	*Procedure for levy of betterment charges* At any time after the expiry of one month from the date of publication of the notification referred in section 8, the Government may cause a schedule of betterment charges to be prepared for all lands included in an irrigation scheme showing the rates at which the charges shall be leviable and payable by the land owners and persons having interest thereon and the properties in which the charges shall be so payable. Provided that the total amount of levy on the total land in respect of any particular scheme will not exceed the total amount spent on the schemes by the Government including interest charges for the number of years in which the betterment charge is to be recovered in equal instalments.

Annexure II — Basis for Betterment Levy

The following statement summarises the basis of betterment levy in respect of the following States :

No.	*State*	*Basis of Levy*
		Acts
1.	Assam	Degree of benefits conferred on lands ; object is to recover the initial cost of scheme in full or in part.
2.	Bombay	Increase in capital value of land on the completion date over that on the construction date (or commencement of work).
3.	Punjab	Increase in value of land with reference to such date prior to commencement of work and estimated value with reference to such other date after such completion.
4.	Pepsu	Increase in value of land (same as Punjab)
5.	Rajasthan	Increase in capital value of land (same as Punjab)
6.	Mysore	Increase in value of land according to rule making power in fixing rates. Generally, will not exceed Rs. 500/- per acre.
7.	Hyderabad	Increase in value of land on the basis of market rate of dry or wet land in the area or its vicinity.

(*Continued on page* 30)

Our Delhi Letter

(From our own correspondent)

Flood Control Plans

The flood control problem for which a very intensive programme of protection works has been sanctioned and implemented by Government all over the country, still occupies a foremost place in the measures taken to improve the lot of the common man for whom devastation by floods has been a recurring scourge. The plans evolved by engineers are being put on models at the Poona and Malikpur hydraulic stations in order to forecast the behaviour of the mighty streams which bring the disastrous floods. The techniques have been expanded in order to include the aspects which so far have not been represented on models. These cover the question of silt charge in the flood waters. Various types of spurs and revetments have been simulated to withstand the attack from the flood waters. The atmosphere is however one of suspense and anxiety because the factors which create the problem cannot be represented on models. One such factor is in evidence on the Brahamputra river where the town of Dibrugarh gets attacked annually. The mountain ranges, from which the tributaries of the Dibru river flow, geologically speaking, are relatively young. The region is, therefore, not at all stable. Earthquakes are a constant feature of the region and every earthquake creates upheavals and sinking of the bed of the streams with consequent silting and scouring. This sudden change in regime besides being unpredictable does not allow final solutions to be worked out on model tests. The efforts of the engineers have, therefore, necessarily to be limited to the protection of obviously vulnerable places. For this purpose, stone bunds have been constructed as far as reasonably economical. The rest of the bunds have been made with locally available material like bamboos, trees and brushwood.

As the transportation of the material is a major bottleneck in the construction of these protective work the Central Board of Irrigation and Power Research Committee had suggested the use of soil cement for the construction of these works. This type of construction requires intimate correlation with scientific analysis of the materials and close supervision by engineering and research staff to secure the desired degree of uniformity of fixing and compaction. It is to be hoped that further initiative will be taken in this direction and the cost of the works considerably reduced by the adoption of this proved material.

Regarding the Kosi, the embankments which are being made must be regarded as a temporary solution because the amount of sediment that this river brings into the plains is far too much to permit the regime flow conditions in a confined bed. Hence the abandonment of the high dam in the Kosi gorge can at best be regarded as a postponement. Control of the volume of floods by means of a storage reservoir would alone have enabled the achievement of the requisite restraint on the vagaries of the flood channels.

Looking at the models of these works at Khadakvasla hydraulic station and Malikpur, one feels enthused that the scientific quest must one day be rewarded with effective solution. Since the taxpayers' money is being spent on very heavy rate on these projects it is of the utmost importance that people are taken into confidence about the real difficulty of the problem. It would not be right to paint a rosy picture and say that a final control over the flood calamities has been secured. One is sometime apt to be amused at the degree of over-confidence with which the enthusiasts of the embankment school of thought predict their final victory.

A problem of a smaller magnitude, which brings equally great devastation and inconvenience, is to be seen in the choes of the Hoshiarpur District in the Punjab. These little streams are dry for ten months in the year and come down in raging floods during the monsoon bringing a lot of sediment with them due to lack of afforestation. The sediment sweeps the beds of the torrents in an ever changing course and big encroachments are made on fertile land and houses and shops. Some of the bridges of the railway and road get completely choked and flooding of the country side results causing immediate loss of life and property and subsequent inroads of malaria and insanitation. The Government of India, on the representation of the Punjab Irrigation Branch have permitted a large field experiment to be carried out for the training of these choes. The scheme broadly consists of confining the discharge of these torrents into selected channels by a system of bunds and cuts. This type of work enables a large contribution to be made by the local people who are adversely affected. Although there is a good deal of controversy about the eventual success of these methods, it is a good and desirable beginning because the theoretical solutions need to be put under the acid test of practice. The work however requires a very responsible planning and supervision because its failure will not only cause a big financial loss to the State but also shake the confidence of the people.

Irrigation and Power in the Second Plan

Encouraged by the success of the First Five Year Plan, the Planning Commission have indicated that they are ready to embark on the 2nd Five Year Plan with greater vigour and in a three times increased scope. A big portion of the plan is again built round Irrigation and Power Projects. The mere fact that India has become temporarily selfsufficient in food, need not minimise the dangers that would again raise their heads once the monsoon fails or is over-active. Drought and floods still constitute a big menace, which can upset the delicate knife-edge balance.

Hence the dictates of realism must still remain paramount and no relaxation of the tempo or the

targets can be permitted. As it is, there are vast deserts in the country stretching from Delhi into Rajasthan, where the simple and sturdy sons of the soil thirst for every drop of water and man and beast quench the thrist of the body in washing and drinking from the same dirty pool. Real prosperity can only emerge when the deserts of Rajputana are converted into smiling gardens like California in U.S.A. and Lyallpur and Montgomery in West Pakistan.

All this is feasible now that hydel and thermal power (and atomic power) are increasingly in the horizon. But the fruition of this ambitious goal is contingent on a lot of preparatory work being first put through. Topographical surveys, soil surveys, load surveys and above all man power planning must be developed in a business-like manner to a degree where the preparation and execution of projects is reduced to a science and technique from which the best results can confidently be expected.

Delegation to U.S.S.R.

Great honour and recognition have been shown to Irrigation and Power representation in the 14-man delegation of technical experts who accompanied the Prime Minister's party in his historical visit to U.S.S.R, Europe and U.K. It was only proper that in this economic resurgence of Asia, Indian technical leadership plays its full part. In Mr. Kanwar Sain, A. C. Mitra, and M. Hayath, India has confidence regarding proper spokesmanship, vision and courage. It is to be hoped that on their return, these engineers speak out their minds boldly and effectively, so that a correct perspective results and the barriers of red-tape and narrow financial considerations do not impede the course of development which the Journal of Power and River Valley Development have been advocating ever since its inception.

Third Seminar of Enginners

The Third Engineers' Seminar held at Srinagar during the middle of July, 1955 is a token of the great upsurge of thought that has welled up in the engineering community incharge of the country's River Projects. On its agenda the principal items are a proposal for a National Construction Corporation and important changes in the Organisation and Administration of River Valley Projects. The question of the strength of technical personnel in various categories is also receiving attention. Another principal item is the question of rates and costs. This has been gone into in great detail in order to explore ways and means for remedying some of the defects in the rate structure of the various non-standard schedules which are prevailing on the various projects. For this purpose a committee had been appointed by the Government of India over a year ago "to evolve a comprehensive standard schedule of rates including detailed analysis of such rates for the major items which can be used as a basic schedule for all projects". The committee of experts who had been appointed for the purpose have got out the first part of their report dealing with rates and costs.

New Era in River Valley Projects

It has to be admitted that India is on the threshhold of a new era so far as the River Valley Projects are concerned. The principal factor that operates in the economy of India is admittedly the monsoon, which is notoriously uncertain and variable. Certain regions receive not even a fraction of their annual statistical share. On the other hand many regions get such copious rainfall in severe intensity that the rivers and torrents over-flow their banks and submerge and devastate huge areas of land. The toll that is taken of the crops, houses and other properties including livestock and human beings is enormous and it is quite customary to hear eloquent appeals from the country's leaders to donate help for the relief of the stricken people. The River Valley Projects are, in the ultimate analysis, meant to provide all the insurance against the vagaries of the monsoon. Simultaneously they have to generate hydroelectric power which is to solve the problem of the country's industrial prouction. It is just as well that the Second Five Year Plan of India is giving further impetus to the programme of river Valley Project construction which figured so prominently in the First Five Year Plan.

Socialistic Pattern

The time has come when the socialistic pattern of Government should make it essential that we proceed boldly with the various projects and fullest initiative is displayed in the undertaking and completion of the outstanding 20 or 30 projects in the various parts of the country. Paucity of funds for these projects cannot be allowed to form an insurmountable stumbling block in the way of their progress. It is a well known fact that returns from projects within a few years after their completion will offset the capital outlay without any element of doubt. Hence if the country has to embark on a really bold programme of construction the financial deficit may well be made up by borrowing or by deficit financing. Not long hence the projects that are already completed will yield enough return to fill up the gap. Meanwhile the additional production of food grains and electric power will make it impossible that any objectionable degree of inflation may take place. The confidence of the people and their enthusiasm for completion of the programmes are the main pillars over which the edifice of River Valley Projects can be securely founded.

Need for Publicity

For this purpose it is essential that great publicity may be arranged so that all sections of the people become aware of the urgent programmes of river valley projects. The people of the country are no longer idle spectators in the field of development. They look out for possible weaknesses or lapses on the part of the planners and executives and it is indeed a poor state of affairs if they are not taken into confidence at a sufficiently early stage when any failures are anticipated. The health of a democracy is based on an element of mutual confidence and spirit of comradeship. It is by this spirit that India expects to

achieve her objective of raising the standards of living of her people by their cooperative efforts.

Personnel still the main bottleneck

The course of progress on the various projects has made it more clear than ever before that the requirements of personnel for the various projects are much greater than has ever been believed in our past experience. When the country wants to advance simultaneously on the projects in every province or state, the total requirements are bound to be much larger than has been previously admitted. Again, it is short sighted economy to let a project linger on simply on account of want of personnel. The interest and depreciation charges on the large jobs mount up so rapidly on account of the machinery element that it now pays to save every single day out of the target period fixed for every project. For this purpose there has to be complete elasticity in the organisation and its expansion or contraction must conform to the requirements of the job. It is a well known fact that the requirements of every job demand seasonal increases in the manpower employed on the job. Such variations are functions of the seasonal characteristics of every job and a wise organisation is always ready to take advantage of all favourable elements in order to expedite the ultimate completion of the job. For this purpose elasticity and flexibility are two essential requisites of the organisation and the engineers in charge of projects must be able to adjust the organisations. This presumes complete delegations to the Head of the Organisation to be able to recruit more persons or disband some personnel. At present it is well-known that weeks and months elapse before the demand of the job can be suitably met. It is high time that Government Organisations modify their rules so as to fall in line with the requirements of speedy construction methods.

Speedier completion of projects

Two items have great importance in the River Valley Projects. The first of these two is the speedier completion of the remaining work on the various projects already under taken in the different parts of the country. This should be pursued as a matter of outriding importance because on its successful culmination depends the confidence of the people. With these projects completed, India will become much more self-sufficient in the question of food and power.

Policy for flood control works

The second item is the question of dealing with floods. There can hardly be any simple way in which the angry moods of nature can be met in the various regions of the country. Generally nature takes man unprepared. It is, therefore, important that the general question of flooding and drainage be tackled all over the country in a scientific and realistic manner. For this purpose the efforts and will of the local people and their leaders in the field of adminstration and technique are all important. No solution imposed by the centre can succeed as easily as the efforts of the people themselves. The guiding principle would be that technical data and research be vetted by the Centre in coordination with the State Organisations. The basic factor is that the people inhabiting the threatened and vulnerable areas should themselves become alive to the urgency of the problem. Moreover, the constructive efforts should not remain confined only to the months soon after the tragedy but the consciousness should prevail all through the 12 months and time should be gained in order to construct defences well in advance of the expected attack. It is a matter of common observation that the stricken people start repairing and rebuilding their houses at the very spot where they had been taken unawares by the floods. The recurring expenditure of repairs and the losses that have to be faced on account of the incidence of attack whenever the rivers get flooded make it essential that more radical solutions be adopted. The problem is not very different from the case of a patient who eventually decides to undergo an operation of the organ which continually gives him disease and trouble. Now that the Union Minister for Irrigation and Power has emphatically pronounced that the habitations which are situated in the low lying areas must be physically removed and shifted to relatively high ground available in the vicinity, it will be a matter of few years that much of the misery that is now inevitable will have disappeared for ever.

Vital stage of Bhakra Nangal

The country's biggest River Valley undertaking namely, the Bhakra Dam Project, is reaching a vital stage as the layout and erection of the Construction Plant has nearly been completed. In less than three months the operation of pouring concrete in the foundations will be started so as to complete the massive structure in the succeeding four years. Five million cubic yards of concrete are to be poured and this big drama will certainly attract the attention of the whole country. With the special foundation problem which the Bhakra Dam has presented, India will justifiably feel proud of the achievement and this dam will be the forerunner of many other dams in the length and breadth of the country. It is important that the organisation which is managing this giant undertaking will be able to offer its experience for utilisation on other projects of the country. In fact after the Bhakra Dam is completed there will be hardly any necessity for importing foreign experts for executing the River Valley projects, except in the role of consultants on some of the intricate problems.

(*Continued from page* 10)

Statement V.L.

Statement of Reservoirs: information extracted from C.B.I.P. No. 51

Very Low Silt Deposit

(16 Cases)

S. No. as in CBIP No. 51.	*Name of Reservoir*	*State*	*Annual Silt per Sq. Miles. (C. Ft.)*	*Catch-ment Area Sq. Miles*	*Contents M.C.H.*	*% Run-off*	*Geology or Nature of Rock Soil etc.*	*Croping*	*Slope*
47	Dhupdal	Bombay	5,700	1,080	1,470	1.2	n.g.	Cultivated	n.g.
161	Paricha*	U.P.	4,500	10,400	2,200	0.7	Granite	M.	M.
162	Dhukwan	U.P.	4,000	8,240	2,400	1.0	Granite	M.	M.
163	Bariapur*	U.P.	Nil	7,700	200	0.07	n.g.	n.g.	n.g.
164	Gangao	U.P.	3,500	7,200	2,100	0.8	n.g.	n.g.	n.g.
165	Lachura*	U.P.	1,500	3,240	740	0.5	?	n.g.	n.g.
167	Ghaggar	U.P.	Nil	310	5,400	n.g.	Rocky	n.g.	n.g.
168	Pahuj	U.P.	4,000	120	320	14	n.g.	n.g.	n.g.
169	Barwa-Sagar	U.P.	9,000	71	360	28	n.g.	n.g.	n.g.
172	Tendula & Sukha	M.P.	7,500	319	9,800	66	?	Jungle	M.
174	Maram Silli	M.P.	7,000	187	5,700	65	Granite Vindhya	n.g.	n.g.
175	Khairabad	M.P.	Nil	16.5	580	58	Gneiss	n.g.	M.
184	Pindraon	M.P.	Nil	9.8	370	58	M.	n.g.	M.
194	Pangri	M.P.	Nil	3.3	90	43	Med	Jungle	Steep
201	Maroda	M.P.	5,000	1.7	50	72	Soft	Partly	n.g.
207	Abhanpur	M.P.	2,600		10	23	Soft	n.g.	Flat

*There is an upper reservoir on the same river in these cases.

Basis for Betterment Levy

(*Continued from page* 26)

BILLS

8. Andhra — Increased value of land equated to 25 times the net additional income minus expenses incurred.

9. Madras — Increase in capital value of land equated to 10 times annual increase in gross produce based on the average of prices prevailing during three years preceding commencement and three years after completion.

10. Travancore -Cochin — The annual increase in the *gross produce* of each class of land which will to estimated with reference to the average of prices prevailing during the 15 years immediately preceding the date of such estimate.

11. Orissa — Based primarily on the increased yield that different classes of land will give under irrigated conditions.

12. West Bengal — Increase in the capital value of land resulting from the execution of the development schemes—excess of value on date of completion over that on the date of commencement of of execution.

13. Saurashtra — Increase in land value ; betterment levy at Rs. 100/- to Rs. 250/-per acre of the commanded area or nearly $\frac{1}{3}$ cost of the project —more related to capital cost of scheme.

14. Madhya Bharat — Increase in land value (as in Punjab).

15. Bihar — Increase in land value (as in Punjab).

16. Himachal Pradesh — Portion of the cost of the project.

Editorial

River Valley Development and Forestry

Soil erosion is admittedly one of the gravest causes of floods. The role of forests in flood control needs to be appreciated much more than is done at present. Possibly a relatively lesser attention paid in this direction is due to the fact that this method is a longer and persevering one compared to the others. But the more the subject of flood control is studied the more convinced would one become of the all-important influence of forests and vegetal cover over land.

The Fourth World Forestry Congress held in India at Dehra Dun last year gave considerable time to discussing this very important topic. Regarding the protective role of forests, the Congress states *inter alia* that "Forests and the grasslands frequently associated with them in nature afford in some cases protection that they alone can provide (lands naturally best suited to permanent forestry), e.g., protection against the desiccating effects and erosive action of winds; protection in mountain regions against avalanches and rock falls; protection of springs and the steep banks of water courses; the stabilisation of moving sand; and perhaps even an improvement in the purity of air in the neighbourhood of towns."

It is therefore necessary to study the various effects of the forest and forest-grazing lands on soil, water, climate, etc. The Forestry Congress, therefore, recommended :

"(*i*) That research on forest influences, particularly in catchment areas be pursued or initiated in all parts of the world with a view to determining the influence of types of vegetation, extent of afforestation, treatment of the forests and grazing lands, and other factors, on water-supplies and erosion.

"(*ii*) That such research be undertaken on comparable methods to be studied by the appropriate international organisations, involving the full participation and co-operation on the part of all interested technicians, e.g., meteorologists, hydrologists, agriculturists and foresters.

"(*iii*) That F.A.O. in collaboration with IUFRO and, if necessary, with other scientific international organisation such as UNESCO, undertake to collect and synthesise results of experiments and observations already available from a number of countries; to disseminate such information for the furtherance of research and for the guidance of countries in their policy of land use including conservation of existing forests and afforestation."

As regards catchment basins of rivers, the Congress states :

"The protection of steep slopes in catchment basins is one of the instances where the forest cover is indispensible. In regions that are over-populated or excessively grazed, forests or grazing lands are often degraded or even completely destroyed. Any valley development project aiming at the utilisation of natural water-supply entails the restoration and the maintenance of the lands concerned through their protection by an adequate cover, not only to the benefit of the engineering works involved but also to that of the local population.

Consequently this Congress recommends :

"(*i*) That where valley development projects are undertaken, prior attention be given to the catchment from forestry angle, with a view to reduction of costs, better efficiency and longer life of the engineering works involved.

"(*ii*) That in catchment basin control, close co-operation between engineers, foresters and agriculturists be accepted as essential for preparation of a comprehensive plan of land use, an adequate topographical map being equally essential.

"(*iii*) That, as finance is a limiting factor, investigation of the cost of the minimum essential work and of probable value of the return to be expected from protective works be undertaken.

"(*iv*) That social conditions, land use systems and agricultural practice of the affected population be given due weight.

"(*v*) That F.A.O. help in spreading technical knowledge on torrent control and catchment area management, by organising in the various regions Working Groups similar to the Working Group on torrent and avalanche control of the European Forestry Commission. These groups would work in close co-operation with other International Organisations interested, such as the ECAFE in the Far East."

It will thus be seen that quite a lot remains to be done in this respect. In fact sufficient emphasis in this direction has yet to be laid in our river valley projects.

Book Review

Rural Electrification. prepared by the ECAFE United Nations Publication, price : $ 0.800.

The present report analyses the problem of rural electrification in the countries of the region. Various technical and economic questions relation to electric power development in rural areas are discussed and suitable methods and practices are suggested. The financial considerations relating to rural electrification projects are dealt with in some detail as finance is the greatest single obstacle faced by all the countries. The report points out that, for a number of reasons, the economics of rural electrification schemes cannot be judged on the same basis as those of ordinary commercial enterprises and that it accordingly appears necessary for the governments concerned to accept the main responsibility for promoting rural electrification and for bearing the financial burden involved through one or other of the various methods described in the report.

The publication has a number of very useful charts and appendices relating to technical aspects.

Annual Bulletin of the International Commission on Irrigation and Drainage, 1954 published by the Secretary General from 1, Old Mill Road, New Delhi-1. Price Rs. 10/-

The Bulletin contains, as usual, some excellent contributions on irrigation and drainage problems in many parts of the world such as India, Thailand, Netherland, Switzerland, France, Morocco, Israel, etc. Some of the welknown contributors include Dr. Charles Jaeger, Dr. N. K. Bose, Kanwar Sain, Dr. L. J. L. Deij, D.V. Joglekar, Otto Huber, M. Ram, C. H. Dobbie and many others. Research activities in various countries have also been described. The Bulletin also contains technical discussions of the Second Congress on Drainage and Irrigation.

Indian Journal of Meteorology and Geophysics. (Geomagnetic Number), published by the Indian Meteorological Department, available from Manager of Publications, Civil Lines, Delhi, price Rs. 6/-.

This is a special number commemorating the Golden Jubilee of the Magnetic Observatory at Alibag, Bombay

The Colaba and Alibag Observatories together provide continuous records for over a century for a station near the geomagnetic equator. Among the contributions made by India to the progress of this branch of science may be mentioned the discovery by Broun of the 27-day period in the daily variations of the earth's magnetic field from Trivandrum observatories, the study of daily lunar variations and its dependence on solar time by Broun and Chambers, and of the time variations of the magnetic field association with magnetic storms which was initiated by Chambers and worked out later in great detail by Moos.

It is therefore quite befitting to celebrate the occasion. The large number of eminent meteorologists from abroad who have either contributed to this issue or sent their felicitations shows how greatly this work is appreciated. The special issue itself marks a great step and we convey our greetings to the Meteorological Department for bringing out this Number, in addition to the very important work that it is doing in this sphere of science.

The issue contains 25 original contributions.

Irrigation and Agriculture in the First Five Year Plan An Appraisal Vol. II by N. S. Joshi, B. E. (Civil), M. R. San, (Lond) and B. R. Dhekney, M.A. Ph. D. published by Deccan Book Stall, Poona-4, pp. 170 price Rs. 3/-.

We have already reviewed the Vol. I of this book previously in this journal (Vol. V. No. 1). This second volume deals with subjects like : Adequacy of Capital for Irrigation Works, Duty of Water and Outturn by Irrigation and Manures; Limitations in Additional Produce by Irrigation and Manures; Discharging Capacity required by Canals ; Distribution of Irrigation Benefits, Utilization of Irrigation Facilities

The arguments and marshallingof facts in the present volume are as effective and challenging as in the previous one. One would have wished that the get up of the book were better and printing mistakes fewer.

River Behaviour, Control and Training (Synopsis) published by the Central Board of Irrigation and Power, pp. 25.

A considerable amount of work on river training has been done in India, and description of these have been published in the Annual Technical Reports of various Research Institutes and of the Central Board of Irrigation and Power. However, the need of a comprehensive manual covering all aspects of river behaviour, control and training has long been felt and the work of compiling such a comprehensive manual has now been entrusted by the Board to the Director, Central Water and Power Research Station, Poona. This manual is under preparation with him and, for the time being, the Board has decided to issue this pamphlet which gives in nutshell, a general idea of the subject and the problems involved.

As a brief review of the types of rivers and the variety of problems and methods and principles of training, etc, this is an excellent summary.

Book Received

Segmental Squares by D. Lazarevic, published by Institute of Hydraulic Engineering, Yugoslavia.

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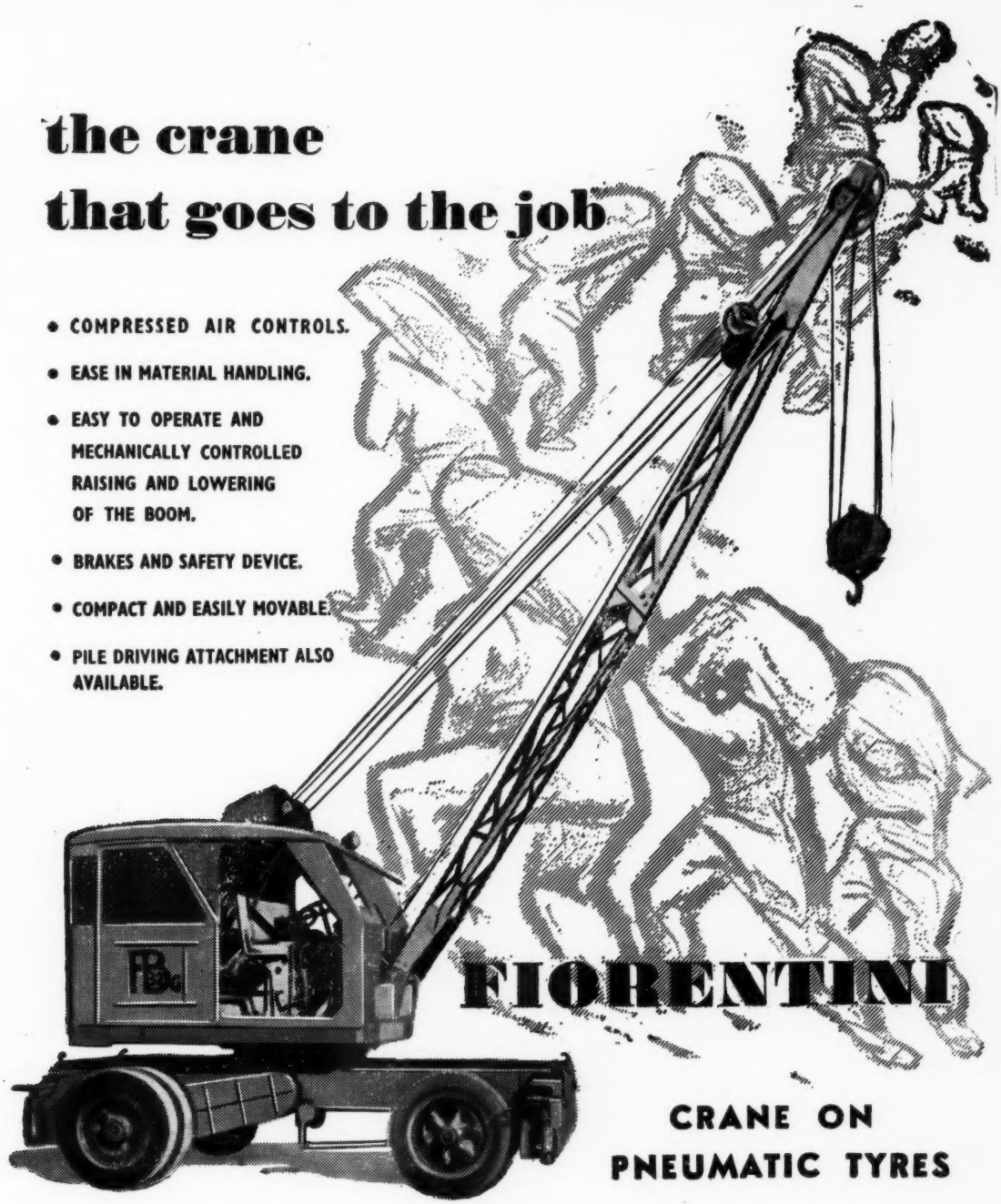

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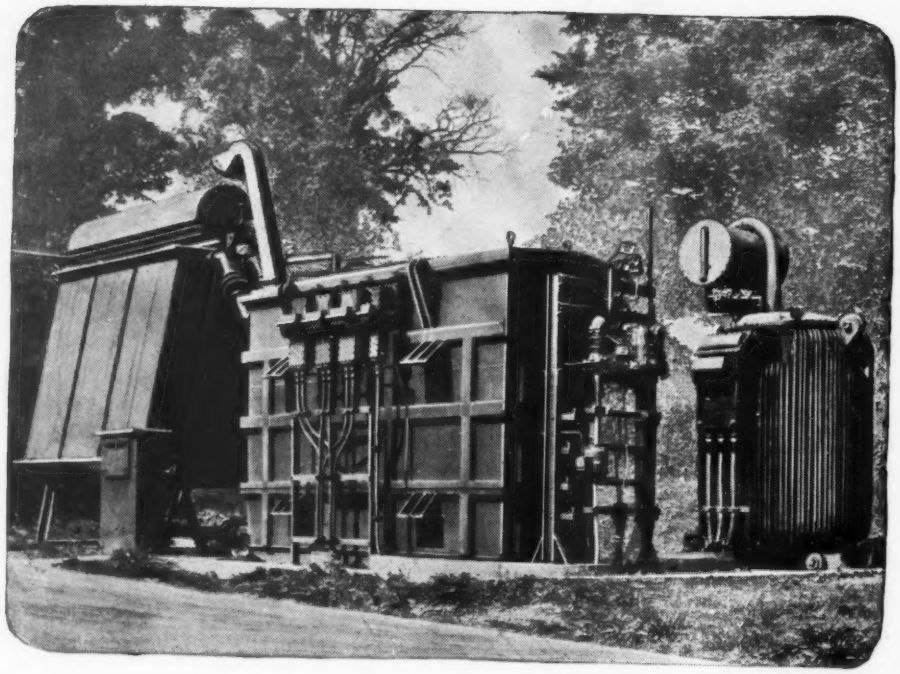

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